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AND PATTERN-MAKER.

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BRITISH FOUNDRYMEN'S ASSOCIATION.

LIST OF SECRETARIES—

General Secretary: J. E. H. Allbut, Reservoir House, Butterley, Derby.

Manchester: H. Sherburn, Rotherwood. Stockton Heath, Warrington.

Birmingham: George Hallstone, 97, Katherine Street, Warley, near Birmingham.

Cardiff: H. Griffiths, Messrs. J. Williams & Sons, Ltd., Globe Foundry, Cardiff.

Sheffield and District: Thos. Swinden, 28, Holland Road, Sheffield.

Glasgow: F. A. Ewen, Messrs. Douglas and Grant, Kirkcaldy.

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Forthcoming Event.

SEPTEMBER 27, 28, AND 29.

Iron and Steel Institute.—Autumn Meeting at Buxton, Derbyshire.

NOTES AND COMMENTS.

The Event of the Foundry Year.

We do not think that any apology will be required by our readers for allowing the report of the British Foundrymen's Annual Convention to monopolise so much of the current number of the FOUNDRY TRADE JOURNAL; that gathering has attained such an importance that it is looked upon in most foundry circles as the occasion of the year. The enthusiasm of the members, this year was not one whit less than on former occassions; in fact, last month's meeting was acknowledged to be one of the most successful, if not the most successful, in the history of the Association. It is interesting to note that the lecturers whose services were enlisted all occupy the first rank in their professions, either as metallurgists or practical foundrymen. The standard of the papers, also, is worthy of comment, particularly as regards the malleable cast-iron industry; for representatives of two of the most prominent firms in England and Sweden, respectively, offered freely to the foundrymen information that it would have been extremely difficult, a few years ago, to wring from any malleable ironfounder. It is clearly indicated that the malleable cast-iron trade is rapidly developing out of its old cloak of secretiveness, and while it is probable that there are still a good many points of procedure that will be more or less carefully guarded for some time, as regards general practice the trade is not now afraid of the light of publicity.

As regards the other papers read before the Convention, little need be said here. Mr. Mason speaks with sufficient authority on the question of the cupola for his contribution to be very valuable, particularly as most of his essential contentions were well supported in the meeting by other foundry authorities. Mr. Swinden's paper on "Cupola Slags," while rather too scientific for the average foundryman to readily digest, deals with an important subject, and one which will have to receive increasing attention in the future. The question of coke dealt with by Mr. Knowles brought out the usual lusty crop of varying opinions, but each discussion on this important question sees more points elucidated, and a few more facts established. The dissertation on "The Constitution of Brass Alloys," by Mr. Hudson, is a fair indication of the progress which the science of the non-ferrous alloys has made in the course of the last few years, and it points to the establishment in the future of something like a basis on which alloying may be done, instead of the old empiric methods. Another subject which has made some progress, but which is still in a very unsatisfactory state, is that dealt with by Mr. Mather in his paper on "Hardness Testing"; while the contribution on "The Electric Furnace" deals with what might be termed one of the more juvenile phases of foundry progress, though one that is destined to grow greatly in the near future. Taking the proceedings of the Convention as a whole, including the discussions—a not by any means unimportant feature—it must be confessed that the Association is progressing steadily. Next session's Branch meetings, where the really educational work is done, will doubtless be increasingly supported by the foundrymen of Great Britain.

British Foundrymen's Association.

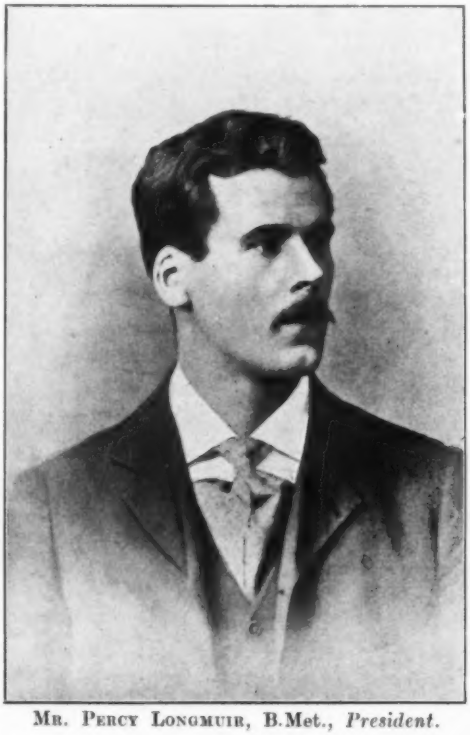
Seventh Annual Convention.

The Seventh Annual Convention of the British Foundrymen's Association took place on Tuesday, Wednesday, and Thursday, August 2, 3, and 4, in Manchester, the city in which was held the inaugural Convention of the Association in 1904. The two first days were occupied by business meetings and discussions, and visits to works in the afternoons, the third day being given up to a most interesting and enjoyable excursion to Chester and places of interest in the neighbourhood of that city.

For the purpose of the meetings the municipal authorities had generously placed at the disposal of the Association rooms in the magnificent School of Technology, an institution of which Manchester is justly proud. Apart from its convenience, no building could have been more appropriate for such a gathering. Not only is it a great centre of technical instruction and metallurgical research, but it also stands upon an historic site. It occupies the ground on which formerly stood the foundry of Sir Joseph Whitworth, who did so much to advance the knowledge of the ferrous metals and the progress of modern methods for their utilisation.

The attendance at the opening of the Convention on August 2, was by far the largest in the history of the Association. The proceedings included a civic reception, an honour to which the members in recent years have become accustomed, and which on this occasion was conferred with a grace and heartiness at least not exceeded in any of the previous instances. The welcome was given in person by the Lord Mayor of Manchester.

The general arrangements were undertaken by a local Reception Committee, of which Mr. R. W. Kenyon (President of the Manchester Branch) was Chairman, and Mr. H. Sherburn (Warrington) was Honorary Secretary—Mr. Sherburn being also Honorary Secretary of the Manchester Branch. The headquarters of the Convention were at the Grand Hotel, Aytoun Street, near the centre of the city and within a short walk of the meeting place.



Mr. Percy Longmuir, B.Met., *President.*

Mr. Percy Longmuir, B.Met., received his training under Professor Arnold in the Sheffield Technical School, now incorporated in the University of Sheffield. After a varied works experience he returned to Sheffield in order to carry out original research at the University. This work, conducted as a Carnegie Scholar, appeared in the proceedings of the Iron and Steel Institute under the heading of "The Influence of Varying Casting Temperature on the Properties of Castings." From Sheffield Mr. Longmuir went to the National Physical Laboratory, Teddington, in order to take up work as one of the research assistants on the work of the Alloys Research Committee. The results of this work form the 7th Alloys Research Report by Carpenter, Hadfield and Longmuir. Returning to Sheffield five years ago, Mr. Longmuir commenced practice as a consulting metallurgist. He has written largely on metallurgical and industrial subjects; is author of "Elementary Metallurgy," and joint author of "General Foundry Practice" (McWilliam and Longmuir). He is a Carnegie Medallist of the Iron and Steel Institute, a Bachelor of Metallurgy in the University of Sheffield, and for a period of three years was external examiner in Metallurgy to the University. Mr. Longmuir is an original member of the Foundrymen's Association and has contributed various papers to its proceedings.

The opening meeting was held in the room which is well known in connection with other technical conferences as the Scientific Society's Room, and which is the meeting place also of the local Branch of the British Foundrymen's Association. Among those present were Mr. F. J. Cook (Birmingham) retiring President; Mr. Percy Longmuir, B.Met. (Sheffield), President-elect; Mr. C. Jones (Cardiff), Vice-president; Mr. R. Buchanan, F.S.A. (Birmingham), and Mr. H. Pilkington, M.Inst.C.E., M.I.Mech.E. (Sheepbridge Coal and Iron Company), Past Presidents; and the following other members of the Council:—Messrs. J. Ellis (Southampton), R. W. Kenyon (Manchester), R. Mason (Wigston Foundry Company), T. McFarlane (Horsehay), W. H. Sherburn (Warrington), J. Smith (South Shields), F. W. Finch (Gloucester), Hon. Treasurer; J. Oswald (London), J. E. H. Allbut (Secretary. Among the members and visitors present were:—Messrs. H. M. Grandidge (Bury), T. H. Hanley (Gorton), F. W. Robinson (Wrexham), G. N. Mather (Ashford, Kent), W. Jewson (Dereham), W. Smalley (Castleton), Alfred E. Dowding (Weymouth and Fiuma, Hungary), W. Gill (Garston, Liverpool). J. A. Smethurst (Warrington), A. Sutcliffe (Manchester), A. Farnson (Castleton), J. Fearsey (Lincoln), F. Critchley (Bolton), A. Hughes (India), F. Penlington (Manchester), J. B. Tattersall (Birmingham). W. R. Wilson (Liverpool), D. Cartwright (Coventry). G. Mill Palmer (Manchester), J. Kenyon (Manchester), A. Ludwig (Manchester), D. Cordingley (Newton le Willows), S. Sumpner (Manchester), George Buchanan (Manchester), Richard Mather (Middlesbrough), T. Swinden (Sheffield), V. L. Cannell, (Newark), F. B. Holt (Leeds),

Alfred Sixsmith (Carron), F. Shaw (Gruxley), R. A. Miles (Heywood), W. H. Thwaites (Sheffield), H. F. Baker (Manchester), J. Shaw (Dudley), E. Blunt (Dudley), W. McVie (Blackburn), D. Campbell (Falkirk), Robert Clark (Falkirk), F. G. Goodwin (Sheepbridge), W. Underwood (Sheepbridge), J. E. Grace (Warrington), W. Sherlock (Lower Broughton), Thomas France (Hardwick), James Kirk (Reddish, Stockport), J. Bentley (Manchester), J. Hill (Wednesfield), D. C. Lloyd (Wolverhampton), H. Hamer (Darlaston), A. Williams (Darlaston), W. Burmingham (Manchester), H. P. Mason (Oldham), J. Aspinall (Stretford), H. W. Surtees (Derby), E. Kain (Preston), G. Goodman (Horsehay, Shrops.), T. Buchanan (Dublin), F. Hazelt (Manchester), and others.

Apologies for absence were received from Mr. W. F. Bagnall (Sheffield), and Mr. W. J. Morris, members of the Council, Mr. W. Mayer (Dumbarton), and Mr. G. A. Blume (Sweden), who had contributed a paper on malleable cast iron, but was prevented at the last moment from attending.

The Business Meeting.

THE RETIRING PRESIDENT (Mr. F. J. Cook), in opening the Convention, said that he considered the selection of Manchester for this year's convention as most appropriate. Many of them would remember that within a few weeks of the formation of the Society they held their first annual meeting in that city, and, no doubt, they could look back and trace a great deal of the success that had attended the Association to the hearty way in which the arrangements were made, and the hearty good-fellowship that was displayed on the occasion. (Applause). Last year, an arrangement was made by which they altered the classes of membership, and he was quite certain now, after something like eight months' trial, that they did a very wise thing. (Hear, hear.) So much so, that he believed the present would be the first Convention in a new era. It was, therefore, quite fitting that at this juncture they should be meeting in Manchester for the second time in their history, when interesting changes were likely to accrue. They would all feel very thankful to the local committee for the way in which they had made the arrangements, for they seemed to have worked very hard, and he was quite sure he was voicing their sentiments as well as his own and those of the members generally, when he said he hoped the success of the Convention would fulfil their fondest ideals. (Applause.)

The Minutes of the last annual meeting having been confirmed,

THE PRESIDENT said that the only business arising out of the Minutes, was a presentation to Mr. Finch, which would come on in due course a little later.

On the motion of Mr. Jewson, seconded by Mr. Bullock, the report of the Council and the balance sheet were taken as read.

THE PRESIDENT, in moving that they be adopted, said that probably many of them noticed on looking over the accounts that the Council had not made economy their only object. In fact they had not spared the cloth, and it was a surprise to him that they were able to come out with a balance on the right side. They had endeavoured to put everything on a better footing than hitherto, seeing how the Association was growing in numbers and importance. For instance they had had the papers for that Convention printed. He hoped that at the end of the present year they would be in a better position.

MR. PENLINGTON (Manchester), thought that they might with advantage be given more details as to the balance sheet. He noticed that the expenses of one branch exceeded the total of those of the other two, and he thought it would be well if they could have an analysis showing what members had resigned, and who were in arrear, and then they would be able to see how the new system of membership was working. The report told them that they had 32 new associates, and that 31 had resigned, and yet they had 49 associates in arrear with their contributions. He would like a little more light on the balance sheet, if possible, with regard to the Branch expenses and arrears.

THE PRESIDENT explained that the membership was given up to December last year, so that the balance sheet really did not give the state of things under the new rules. The 44 members at a guinea were members previously to the new rules coming into force. As the new rules did not come into force until January 1 this year, there were a number of subscriptions at the new rates which did not come into the balance-sheet. With regard to the expenses of Branches, the question was very often one of the age of the Branch. After a Branch had been going on for several years it was able to get on very much better financially than at the start. Probably, one reason for the heavy expenses incurred by the Sheffield Branch was that the £16 for Sheffield was for the whole of the year, whereas the amounts in the other cases were only for the period up to December. Further, he knew that Sheffield had some difficulty in arranging for meetings. In Birmingham and in Manchester they were more favoured in that respect. In Birmingham they only paid 5s. per meeting, but Sheffield had to pay at a higher rate.

The SECRETARY said that before the alteration of the rules the associates always paid their subscriptions to the local Branches. The 49 associates' subscriptions at 3s. in arrear came under that old arrangement. There were 79 associates, and during the year only 30 paid, so that there were 49 in arrear. He had to put the total number of associates on the income side of the balance-sheet in order that it might correspond with the number on the books. By deducting the 49 given on the opposite side as in arrear they would get the number of 30 as having paid. Forty of the 49 defaulters, he added, had paid up since the end of the financial year.

The PRESIDENT added that they in Birmingham had paid twice in one year, but the second subscription was not paid until after Christmas, and, therefore, did not appear in the balance-sheet.

The report and balance-sheet were unanimously adopted.

Presentation to Former Secretary.

MR. COOK said that it was now his duty to resign the position of President, as the time had arrived for declaring all offices vacant. But before leaving the chair he had two duties to perform, both of which were of a very pleasant character. The first was that of a presentation on behalf of the members of an illuminated address to their present Treasurer and former Secretary, Mr. Finch. (Applause.) They would remember that at last year's Convention a resolution was passed that they should in some way mark their esteem for the work that Mr. Finch had done for them. That movement had taken two forms, one, as in the case of previous presentations, represented a direct gift out of the funds of the Association, namely, an illuminated address. There was, however, a further presentation provided by a public subscription among the members. That, of course, was a deviation from their previous rules, but one which he thought they would agree the circumstances warranted. He was

very pleased to say that the appeal for subscriptions was freely responded to; in fact, in such a manner that they were able to present to Mr. Finch, in addition to the address, a gold watch and gold pendant. That part of the presentation would be made by Mr. Mather. His own duty was to present to Mr. Finch the illuminated address, which they had before them. The text of the address was:—

"To Mr. F. W. Finch.

"We, the members of the British Foundrymen's Association, desire to place on record our sincere thanks for the valuable services you have rendered the Association since its formation. For several years you were our esteemed Secretary, and you have also served with ability the office of Treasurer. As a mark of our high esteem and regard, and as an appreciation of the ability and initiative displayed by you in the conduct of the affairs of the Association, we have much pleasure in asking your acceptance of this address, and earnestly hope that the Association may long retain your valued services."

Mr. Cook then, amid loud applause, presented the address to Mr. Finch, adding that personally it gave him particular pleasure to make the presentation, because for many years he worked as an apprentice under Mr. Finch, who was his foreman, and who taught him all he knew as to pattern-making. Before asking Mr. Finch to reply, he would ask Mr. Mather to present the gold watch and pendant.

Mr. Mather, in making the presentation, acknowledged the services which Mr. Finch had rendered the Association.

Election of President.

Mr. Finch having acknowledged the presentation,

Mr. Cook said that his next duty was also a pleasurable one, and yet he performed it with some reluctance, because having got used to the work, he had become deeply interested in it, and did not altogether like to lay it down. The duty he had now to perform was to propose his successor in office, and though it meant for him the breaking to some extent of the pleasant tie, he recognised that the success and the stability of the Association depended upon the officers rotating. He was quite certain that in electing Mr. Percy Longmuir as their President, they would be doing a great deal towards enhancing the prosperity and stability of the Association. (Applause.) It required no words of his to eulogise Mr. Longmuir, in any company of metallurgists, for Mr. Longmuir was known not only throughout England, but the world over, and they would be doing themselves a great honour in asking him to take over the office of President of the British Foundrymen's Association. He therefore proposed that Mr. Percy Longmuir, B.Met., be President of the Association for the ensuing year. (Applause.)

Mr. Robert Buchanan seconded the proposition, which was carried unanimously.

Mr. Longmuir said:—Mr Cook, Mr. Buchanan, and Gentlemen, I thank you most heartily for the kindness you have shown to me this morning. In many respects I feel not at all suitable to occupy this position, but none the less I mean to try my best, at any rate for the year. In accepting your kindness I should like it to be quite understood that I occupy this post for one year only. (Cries of "No.") It is after all a pleasant thing to take the chair in Manchester because our first Convention opened here, and in comparing our position then with our position to-day, the intervening years certainly show most gratifying progress. Some of you will remember, I think, the correspondence which went on in The Foundry Trade Journal, before this Association was formed, and as an index of my views to-day, I may read one paragraph from an article I wrote for that journal in December, 1903:—

"Considering the importance of the foundry industries and their unrepresented character, there should be a most extensive field for such work. Further, the daily routine of any iron, steel or brass foundry is sufficiently convincing as to the actual need of wider knowledge. Comparatively few foundries work under identical conditions, and the difficulties of one shop are not always those of another, even though the two may be producing a similar type of work. Here alone in the matter of common difficulties much valuable information could be derived from an interchange of experience and information."

Those words represent my attitude of mind and the attitude I hope to maintain in the position in which you have so kindly placed me. (Applause.)

Election of Vice-Presidents.

The President (Mr. Longmuir) said that his first duty on taking the chair was to propose the election of their friend Mr. C. Jones, as senior Vice-President. (Applause.) He believed some of them knew that Mr. Jones came from Wales. (Laughter.) At any rate, he was certainly known to all of them. (Hear, hear.) He (the President) had the pleasure not only of proposing Mr. Jones as Vice-President, but also of looking forward to seeing that gentleman in the chair next year.

Mr. Finch said that he seconded the motion with much pleasure. Mr. Jones was a good fighting man, but they were always the best of friends after the battle. He looked forward with great pleasure to seeing Mr. Jones President of the Association.

The proposition was carried unanimously.

Mr. Jones, in reply, thanked the members for the honour they had done him, and expressed the hope that if he should come to occupy the Presidential chair, he should perform his duty with the same earnestness, if not with the same ability as they knew they might expect of Mr. Longmuir. (Applause.)

Mr. Oswald proposed that Mr. R. W. Kenyon be elected junior Vice-President. He thought that a most appropriate time to recognise in some manner the services of Mr. Kenyon at the Manchester Branch, and they could not show that appreciation in a better manner than by electing Mr. Kenyon as one of their Vice-Presidents.

Mr. F. J. Cook, in the absence of Mr. Macfarlane seconded the nomination. They all on the Council knew, he said, the good work Mr. Kenyon had done. He was a good level-headed business man, and that was the kind of man they wanted to work for the Association, while the work he had done for the Manchester Branch was most valuable. He was certain that there was no more popular man whom they could propose as Vice-President of the Association. (Applause.)

Mr. Kenyon:—Mr. President, before you put this I would just like to be allowed to raise a word of protest. (Cries of "No.") Mr. Kenyon added that he did not feel that he was fitted for the position, because it might be regarded by some as a stepping-stone to the Presidency of the Association. Therefore, he would rather not have it because he did not feel equal to it. He simply wished to make it clear that if they did force him into that position and he failed to come up to the standard they required it would be upon their own heads. (Laughter.)

The President said that the Manchester members especially, and those who had visited the Manchester

Branch would know that in electing Mr. Kenyon to any office they need have no fear at all. (Applause.)

The election was unanimously agreed to.

MR. KENYON:—Thank you. I will do my best.

Treasurer and Secretary.

MR. BUCHANAN said that he had to nominate their old friend Mr. Finch for the position of Treasurer. After the presentation they had made to Mr. Finch that morning, it was unnecessary to say a word in support of the proposition for his re-election.

MR. MATHER seconded the motion, which was carried unanimously.

The PRESIDENT said that the next position to be filled was that of Secretary, and he had very much pleasure in proposing that they ask Mr. Allbut to undertake the office for another year. The work of the Secretary was no light task. The work of the President was a mere nothing to it. The Secretary was in harness the year through, and he had a considerable amount of routine work to do. The success of that or any other Association depended in many respects entirely on the Secretary, and the work he put in. In asking Mr. Allbut to take office, he was also, on behalf of the Council, asking him to accept what could not be called a salary, but the small amount of £30 a year as a slight recompense for the work he undertook on behalf of the Association. (Applause.)

MR. COOK said that having been their President for two years, he knew something of the work that was entailed on the Secretary and he was quite certain that there was no one who did his work more conscientiously or better up to time than their Secretary, Mr. Allbut.

MR. A. E. DOWDING said that he should like to endorse the remarks made in reference to their Secretary. As an outsider he was one of those who only got into touch with him by correspondence, but Mr. Allbut's letters had been most courteous and full of goodfellowship, so that one felt that one knew him even before meeting him. (Applause.)

The motion was carried unanimously.

MR. ALLBUT, in returning thanks for his re-election, said that there had been a great deal of hard work connected with the position, but it was gratifying to him to see the results. In 1908, at the Newcastle meeting, he expressed a wish that their membership should be increased to 500. He was glad to say that that wish had been gratified, and he was now looking forward to reaching the 1,000. The Association had not only increased in membership, it had increased in influence. Their membership now amounted to 571, and he was hoping that the increase this year would be over 300. They were making rapid strides. That meant more work, but all he wished was to secure the success of the Association.

The New Council.

MR. F. J. COOK said that six members of the Council had to be elected at that meeting and there were eight nominated. In the ordinary course, they would have to ballot on these nominations, but he was of opinion that seeing that the two new names down were those of men of good ability, and that the Association was growing so rapidly, they could not do better than elect them all. They could not have too many business men on their Council, and he knew that the two new members nominated, were men of that description. Mr. Firth, of Sheffield, whom he knew personally, was a thoroughly good business man who would enhance the reputation of the Association, and, as he travelled about the country a good deal, would be able to do them special service in that respect. Mr. Henderson, was connected with Thornycrofts, a firm of great repute, and was also himself a man of repute. Therefore, he thought they would be doing the best for their Association if they elected to the Council *en bloc* all the members nominated. He could not think of one whom they ought to leave out. (Hear, hear.)

MR. WINTERTON pointed out that there was a further vacancy on the Council caused by the election of Mr Kenyon to the "Upper House."

MR. JAMESON seconded Mr. Cook's proposition, which was carried unanimously. The following, therefore, were elected to the Council. (The names of the members who retired by rotation and were re-elected are indicated by an asterisk):—Messrs. *S. A. Gimson (Leicester), *T. MacFarlane (Horsehay, Shropshire), *J. Oswald (London), *W. H. Sherburn (Warrington), *J. Smith (South Shields), *R. Mason (Leicester), T. H. Firth (Sheffield), G. B. Henderson (J. I. Thornycroft & Company, Limited, Southampton). The Council is now made up of these gentlemen, with the officers and the following other members:—Messrs. R. Buchanan, F.S.A. (Handsworth, Birmingham), W. F. Bagnall (Shalesmoor Foundry, Sheffield), J. Ellis (Flack, Ellis & Company, Southampton), L. Graham (Willans & Robinsons, Rugby). C. Heggie (J. Wright and Eagle Range Company, Birmingham). R. W. Kenyon (Entwisle & Kenyon, Limited, Accrington), C. Morehead (Tynemouth), W. J. Morris (The Butterley Company, Limited, Derby), H. Pilkington (The Sheepbridge Coal and Iron Company, Limited).

Votes of Thanks.

MR. H. WINTERTON proposed a vote of thanks to the Officers and Council for their services during the past year. He said that the members of that Association at any rate might congratulate themselves upon having "a business Government." He should like to add that they owed a debt of gratitude to their friend Mr. Allbut for the very excellent handbook he had prepared for that Convention.

MR. S. G. SMITH (Chesterfield) seconded the motion, remarking that they knew what great demands were made upon the officers of an Association like theirs. Their officers were often working when the other members were at rest. (Applause.)

The motion was put by MR. WINTERTON and carried by acclamation.

The PRESIDENT said that they had nothing to thank him for, but he did think that they had something to thank Mr. Cook for, and he would ask Mr. Cook to reply.

MR. F. J. COOK (ex-President), acknowledging the vote of thanks, said that Mr. Smith was quite right in saying that those who were in office were working for the Association practically all the year through, but it certainly had been to him a most pleasant time, because the whole of the officers had been most enthusiastic in their work. When they remembered that some of the members of the Council had to travel as far as 300 miles to attend a Council meeting, and had never been absent throughout the year, it would be agreed that this said a great deal for their enthusiasm. (Applause.) They received nothing in the way of expenses, and they had at least to stay a night. Therefore, the least they could do was to give to the members of the Council a hearty vote of thanks, and he could assure the members that the business of the Association was being well looked after by their officers. (Applause.)

Life Membership.

The next business was the consideration of the proposed alteration of Rule No. 5. The Council proposed to increase the fee for life membership to 10 guineas. The PRESIDENT then asked Mr. Cook to bring the matter forward.

MR. COOK said that the Council considered that a subscription of five guineas was certainly too little for an Association holding the position to which they had now attained. He therefore proposed the alteration to 10 guineas.

MR. PILKINGTON said that he had great pleasure in seconding the proposition. He had slipped in under the five-guinea rule, but he was quite sure that he was sensible at the time that the thing was altogether too cheap, remembering that the annual subscription was one guinea. He thought those life members who had taken advantage of the five-guinea rule ought to pay up. (Laughter and applause.)

The proposition was carried unanimously.

Welcome by the Lord Mayor.

At this point, for greater convenience in illustrating and discussing the papers, the meeting adjourned to the Physics Lecture Room. Here the Convention received a visit from the Lord Mayor of Manchester, the Right Hon. Charles Behren, who wore his chain of office.

After an admirable address, and the extension of a warm welcome to the city by the Lord Mayor, the PRESIDENT requested Mr. Reynolds, Director of Technical Education for the city, to address the meeting. Mr. Reynolds then joined the Lord Mayor in his welcome to the members, and briefly addressed the meeting on the value of teaching the principles on which the trade rested.

The President responded for the Association, and a vote of thanks to the Lord Mayor and Mr. Reynolds for their kindness and courtesy in giving so gracious a welcome was then moved by the PRESIDENT, and seconded by MR. R. W. KENYON. It was supported by MR. F. J. COOK, who laid emphasis upon the great kindness of the Committee of the School in allowing them the use of the rooms, and in giving them every assistance to make the Convention a success. MR. W. H. SHERBURN also heartily supported the proposition, and stated that when he approached Mr. Reynolds with a view to having their Branch meetings there, Mr. Reynolds met him more than half-way. The work of the Branch, in fact, was considered as much a portion of the work of that Institution as was any other department of its work. (Applause.)

The LORD MAYOR, after acknowledging the vote of thanks, took his leave.

Presidential Address.

The PRESIDENT (Mr. Longmuir) then delivered his inaugural Address as follows:—

Industrial life is not free from the criticism which contends that practice of to-day is decidedly inferior to that of twenty or thirty years ago. We frequently hear statements to the effect that Britain is losing her industrial leadership, and that the new industries of recent years have been of German, French or American origin or commercial development. Public speakers and writers may vary the theme, but the underlying spirit is the same, and that spirit spells degeneration. In private intercourse we meet the same thing, and though clothed in various dresses it still amounts to the statement that "Jack is not the man his father was."

There are some people who boldly assert that twenty years ago failures were unknown. Foundries then produced no wasters, steelworks had no difficulties, and metallurgical problems were unknown. Such a golden age is not familiar to workers of to-day, and as we listen to these stories of other times we are tempted to wonder whether there may not be some truth in the persistent cry of degeneration.

The writer does not associate himself with this feeling, but when newspaper discussions, anent, the "Flabby Age," "Degeneration." "Declining Birth-rate," and kindred topics are rife in general circles, and certain ultra-technical coteries are inclining to the view that to-day's practice is as nothing, then it is time to examine the matter in its relationship to our work.

A glance at current shop practice shows it to be short of perfection in many directions, but in spite of this there are glimmerings of some advance. Some examples of progress are to be found in castings for the torpedo-boat and its high-speed engines; petrol engines and turbines also offer telling examples of development in the art of iron-founding. Steel castings have emerged from the gloom of uncertainty into the glare of commercial daylight. Brass foundry alloys have advanced from secret and pet mixtures into something approaching a tangible system. Knowledge of metals and alloys is increasing step by step, and traditional empiricism is falling away before the slow but certain progression of exactitude. These are merely statements, but they admit of proof and confirmation from experience.

Without attempting actual proof, it may be well to glance for a moment at the commercial side. Rates, taxes and wages have not lessened with the passing of time, and the materials used by foundries have not cheapened. Indeed, general material costs and standing charges are moving upwards. This theme could be developed to a large extent, but a few thoughts only must suffice. Taking first municipal rates as levied in a few typical towns, we have the following record:—

	1895-6.	1902-3.	1909-10.
	s. d.	s. d.	s. d.
Blackburn	5 10	7 4	7 10
Bolton	5 1	5 2½	6 7
Brighton	5 2½	6 10	7 5
Bristol	6 8	7 6	9 1
Hull	7 1	7 5	8 4
Huddersfield	6 10	7 1	8 6
Leeds	7 0	7 10	8 10
Leicester	6 5	7 3	8 1
Liverpool	6 0½	7 0	8 5½
Manchester	6 0½	7 5½	8 6½
Nottingham	6 5	7 9	8 2
Norwich	8 8	7 11	9 11
Oldham	6 1	7 4	7 8
Sheffield	7 8½	8 9½	9 4½
Sunderland	5 8	6 8	8 1
Swansea	6 9	7 1	9 4

These figures become of greater interest when averaged, as for example, taking the sixteen towns we have the following averages:—

1895-6.	1902-3.	1909-10.
6s. 5½d.	7s. 3½d.	8s. 4½d.
	Increase, per cent. 12½	Increase, per cent. 30 over 1895-6 15 over 1902-3

In a similar way national expenditure is rising, and doubtless this upward trend will continue. Taking one or two years, we have the following approximate figures:—

Year.	Expenditure. £
1840-1	49,285,296
1906-7	139,415,251
1907-8	151,872,094
1908-9	152,292,395
1909-10	163,171,000

National expenditure should be viewed in its relation to the increase in population, whereas municipal rates represent direct increases on the assessment, and are not directly related to the growth of population.

There are just and proper reasons for the increases noted, and probably a greater ratio of increment, if properly expended, would result in greater efficiency. The one point for consideration is the fact that industrial burdens of to-day are greater than those of yesterday, and the illustrations given represent an aspect which has a direct bearing on every foundry, whether fully employed or not. These influences are felt on standing charges. Turning to direct charges, it cannot be said that raw material costs have appreciably decreased with the passing of years. In this respect, average figures are not easily obtained, but as one index the following table may be given:—

Year.	Lowest Cash Prices, No. 3 Cleveland.* £ s. d.	West Coast Hematite. £ s. d.
1886	1 9 3	2 0 0
1887	1 10 6	2 0 9
1888	1 10 9	2 0 9
1889	1 13 6	2 4 0
1890	1 19 6	2 9 3
1891	1 17 6	2 6 6
1892	1 14 9	2 4 9
1893	1 13 7	2 4 4
1894	1 14 9	2 2 9
1895	1 14 0½	2 2 3
1896	1 16 1½	2 5 9
1897	1 17 11	2 6 4½
1898	1 19 10	2 8 3
1899	2 9 7	2 17 3
1900	2 10 0	3 3 9
1901	2 2 5	2 15 6
1902	2 3 3	2 15 8
1903	2 1 6	2 14 6
1904	2 1 7	2 11 9
1905	2 5 3	2 15 4½
1906	2 7 2½	3 2 4½
1907	2 8 5	3 6 0
1908	2 7 6	2 17 7½
1909	2 5 7	2 15 0

* Metal Market Year Book, 1910.

These values represent the lowest prices recorded during the years quoted, and they are of interest in showing that on the chief source of raw material no relief in cost has been given to the ironfounder. Other materials show similar features; raw materials, if not actually advancing, are at any rate not reducing in cost.

This cursory examination of a large subject leads to the recognition of several features which may be summed up as showing that standing and direct charges have not decreased generally. Now, the selling price of nearly all classes of castings has decreased, or, in the absence of actual decrease, no increase had been made commensurate with other increments. Therefore, unless the founders of this country are in business for health alone, some progress must necessarily have been made in practice; otherwise increased charges would not be met by decreased selling prices. In regard to selling prices, for obvious reasons no figures are quoted, but personal experience will no doubt give ample confirmation.

Another factor, and one of increasing importance, lies in the specifications associated with certain classes of castings. Generally speaking, these have been successfully met, thus offering further testimony to advancing practice. Notwithstanding difficulties, progress has been made in the art of founding and in the knowledge of the metals handled by the founder. This technical advance is proved by commercial results, and these in turn form an answer to the cry of industrial degeneration.

Whilst insisting on the fact of technical progress, we also recognise that many things are unknown, and this recognition is stronger to-day than it has ever been in the past. This is a healthy sign, for a realisation of the necessity for knowledge is the first step in education. Now, education is a pet theme and a very convenient peg on which to hang a Presidential address; none the less the matter is becoming hackneyed, for nowadays the majority of people recognise the value of education, whether general, technical or commercial.

Education, as ordinarily understood, is recognised, but unfortunately this recognition is in most cases limited to the ordinary technical curriculum. Wider and more advanced work is required, and the writer would like to see this Association developing work of the type so successfully introduced by Mr. Cook and Mr. Hailstone at the last Convention. In other words, we ought to develop a spirit of advanced study and research into the unknown, and in this direction a gentle plea might be entered for the historical side. In looking backward at technical and scientific progress, a few thoughts arise which may be given without in any sense touching on detailed history. Turning back to the uttermost pre-classical times, we find that the earliest efforts at the interpretation of natural phenomena found expression in different mythologies. These popular beliefs represented mental conceptions which to some extent influenced the speculations of the early philosophers, leading to deductions as unscientific as the myths they attempted to replace. But the philosopher developed, and in course of time shook off the clogging trammels of popular belief, so much so that by the time of Herodotus, 500 B.C., the supernatural had, in advanced minds, given way to more natural interpretation and speculation. True, speculation rather than direct observation held chief sway, but real intellectual and technical progress was being made. This continued, and neither priesthood nor popular hatred retarded it. The characteristic bronzes of the ancients eloquently testify to the technical skill attained.

The replacement of classical paganism by Christianity placed no barrier in the way of philosophical progress or technical advance, but the devastation following the Northern invasion of Rome effectually suspended all progress. For centuries, science and technology were dormant. Later, in the Middle Ages, when further efforts began to be made, pioneers had to meet a spirit of intense intolerance unknown to antiquity.

Coincident with the Reformation, Science began to awaken to some of its possibilities, and technical science began to receive some recognition. From about the middle of the 17th century, pioneers of chemistry started its development as a separate science. The history of modern chemistry begins with Robert Boyle, who taught as its main object "the acquisition of a knowledge of the composition of bodies." Incidentally, this Association is established to teach the same thing in so far as is applicable to the bodies used in foundry practice.

This brief survey shows that man has endeavoured to progress by reaching the heart of the mysteries surrounding him. The endeavours may have been retarded by artificial barriers, as in pre-Reformation times; they may have worked in devious directions, as during the alchemistic period; but the tendency of the ages is forward. Is it not evident that a true historical perspective would show the fallacy of statements of lost powers in industry and of inferior workmanship? Historical perspective would show that with the passing years conditions change, bringing into play new features, new problems, and speculations unknown to a previous age.

The rate of development is not now set by one

country alone. The leading industrial nations, in vieing one with another, have increased the rate enormously. It does not follow that the more rapid the development the better the final result, but history shows that those countries which do not progressively develop will eventually suffer commercially. The development of other countries is a point worth most careful attention.

British foundries have no cause for alarm, and the writer has emphasised the fact that progress has been made. Giving full weight to this, we have still to admit that the future will demand more progress than the past. The rate is speeding, but true progress will not be achieved by mere hustling. Byron has it that—"Quiet to quick bosoms is a hell"; but disquiet should not degenerate into hysterical bustle which restless spirits mistake for practical energy. Viewed from a practical point of view, the cheapest producer controls the market. In other words, he who has the most knowledge obtains the best plums. Knowledge, as shown in the equipment and organisation of a foundry, necessarily means power to do good work. The extension of this knowledge is a vital matter to this Association, and such extension means research into the unknown. Research is sometimes regarded as an academic thing, beloved by professors, but of no use to the man of affairs. This is erroneous, for to-day's commercial research means bread and butter for next year. If the foundry managers are certain that their position twenty years hence will remain satisfactory, then let them leave research severely alone and pocket money instead of spending it on improvements following investigation. But how many foundries dare make this assumption?

Those who try to anticipate the future, practice current research, and by patient, persistent delving into daily problems endeavour to locate the cause of troubles in order that remedies may be defined. Commercial research is very fully recognised in Germany, and the industrial results following this research are familiar, and may become more familiar. In 1907 Germany had 2,028 academically-trained chemists employed by 344 firms, and 289 chemical technologists employed by 88 firms. To-day, the most successful industries are those taking advantage of the full range of scientific methods open to them for guidance in present processes and for help in the introduction of new methods. The modern engineer in partnership with the scientist is revolutionising many industries, and the foundry will of sheer necessity have to take advantage of this partnership.

The man of affairs does not hoard his savings in a safe, but invests them with a view to increase. He sometimes spends in order to save. So in foundry management, wise current expenditure will have an effect on future prosperity. One of the wisest methods of spending lies in methodical efforts to increase the knowledge of present practice, with a view to future modifications.

Mr. R. Buchanan said that the review which their President had given them, of scientific thought and scientific work, especially in the present year, by their competitors, was one that should be weighed well, not only by them, but also by all the iron-founders in the country. They could not but agree that the future lay in the hands of the scientific man who had the practical means of following up his scientific thought. He proposed that they give a very hearty vote of thanks to their President for his important, thoughtful, and interesting Address. (Applause.)

The motion having been carried by acclamation,

The President acknowledged the compliment, and explained that the next business would be the reading of Papers.

Discussions on the Papers.

The procedure with regard to Papers this year was somewhat different from that of the preceding conventions. The Papers, having already been printed and circulated, were dealt with very briefly by their authors, or those who represented them, so that there was much more time than hitherto available for discussion.

Properties in Coke.

Mr. F. K. Knowles, B.Met. (Sheffield), gave a brief *resumé* of his Paper on "Properties of Coke" (see page 486), and, in conclusion, read the following communication which had been sent to him by Mr. T. Jobson, F.I.C. (Wm. Jessop & Son, Limited, Sheffield):—

AFFINITY OF IRON AND SULPHUR.

"My attention was called to an occasional and unexpected slight rise in the sulphur content in certain high-grade steel made from Swedish iron and Swedish scrap. An examination showed that the heavy rust on both pig and scrap, which had been in stock a considerable time, contained high percentages of sulphur, chiefly as ferrous sulphide. Some months later, when taking auto-sulphur prints from polished sections of large forgings, I took a print in the usual way (by applying a sheet of bromide photographic paper soaked in dilute sulphuric acid) from a polished surface which had by mistake been left for about 12 hours in the machine shop without a protecting coat of oil. The polished surface showed a slight discolouration when compared with a similar surface which had been oiled. But, as a matter of curiosity, I took prints from both, without further treatment of the surfaces. I was somewhat surprised to find that there was sufficient sulphide present on the unprotected surface to darken the bromide paper all over and obscure any local indications of sulphide for which I was looking. There was, as usual in the winter, an open coke fire in the shop, which was evidently the source of the sulphur compound. Whether the sulphur, as H_2S or SO_2 combines directly with the iron, or a hydrated oxide is first formed, which then takes up the sulphur, is a matter for further enquiry, as is also the question of the bearing of this action on the rusting of iron."

Mr. H. Pilkington, in opening the discussion, said that although he had been interested for some time in the production of coke, he was also very much interested in the consumption of it, and he had never known any common agreement between the producer and the consumer. The proof of the pudding was in the eating. He had eaten a lot of coke pudding, and he was very sorry to say that a great many of the remarks made by Mr. Knowles were such as he could not agree with. Mr. Knowles first of all maintained that practical men judged coke very much more by its appearance than by its chemical composition. That was true, no doubt, to a great extent. They had eaten the pudding, and judged by their experience, but it was not correct to say that they simply judged by appearance. It was wrong to say that they did not think about the chemical analysis at all. He did not think Mr. Knowles actually said that, but it might be inferred from what he did say. Take the transition from the beehive to the by-product oven. There was no doubt that as far as the blast furnace was concerned it had reduced, not greatly increased, the consumption per ton of iron made. It might be said that it was prejudice, but it was the fact that they liked

that silvery appearance, and he thought that the piece which Mr. Knowles had shown them with a black heart was simply a freak. They believed that the coke with a silvery appearance would go down to the bottom of the furnace with less loss than the dirty-looking by-product cokes. He had nothing to say about the commercial possibilities of by-product ovens. They were bound to prevail over the beehive ovens, simply because the commercial possibilities were entirely in favour of the by-product ovens; but in the by-product cokes, chemical analysis itself proved that the superiority was not so great as was suggested. For instance, they were nearly always imperfectly coked, and there was always a certain amount of volatile matter left after coking which they did not usually find in the beehive coke, to say nothing of water, which was not simply left in, but put in. (Laughter.) But the fact remained that, on the whole, Mr. Knowles was quite correct, and that men did believe more in beehive coke, and did largely believe in judging by appearance. Mr. Knowles had referred in one part of his paper to the question of waste in by-product ovens, and had mentioned also that there was no essential difference between the analyses of the plain beehive oven and the by-product ovens. A good deal of that waste in beehive ovens was certainly due to the admission of air, but the coke, as a rule, was perfectly dry and perfectly coked, and a good deal of the extra yield referred to was due to the volatile products left in, and to the added water. The density of the coke was another matter which interested him. He had found some tremendous differences in the weight per cubic yard of samples of similar coke. He agreed that in the cupola the density of the coke was an important matter; but in a blast furnace it was not of so much importance. If a barrow of coke weighed 1 cwt. less and would do the same work, it must be a chemical matter. He believed that density was supremely important in the cupola, while the question of ash was of more importance in the blast furnace. The question of sulphur was of less importance in the blast furnace, where fluxing was more easily conducted than in the cupola. The paper of Mr. Swinden on "Cupola Slags" had some bearing on this matter, because the slag in a blast furnace was intensely basic, and the sulphur contents had to be dealt with, whereas in the cupola they were nearly always more or less acid. He did not know whether Mr. Knowles, in his capacity as investigator, had ever struck the question of phosphorus in coke ashes. He himself had occasionally come across some very serious things in the shape of contained phosphorus in the ash of the coke.

Mr. F. J. Cook agreed with Mr. Pilkington that Mr. Knowles had rather underrated the foundryman of to-day in saying that he judged more by appearance than by analysis. In the Midlands, in particular, he thought as much importance was attached to chemical analysis in the case of coke as in that of iron. In fact, he knew some firms which did a great deal more analyses of coke than of iron. There was no doubt that many cokes had an excess of water, and although they could not always stop them at the furnaces, still he knew firms which specified the percentage of moisture and deducted any excess from the bill. There was another thing, also, to which sufficient attention was not paid. All coke wagons should be sheeted. (Hear, hear.) This did not affect the question of work, because the heat going up from the cupola drove off a great deal of the moisture, and he was not sure that the moisture was not in some way beneficial, because it kept the heat lower down in the cupola; but, certainly, they should specify the percentage of moisture and deduct from the payment the excess, and should also insist upon the wagons being sheeted. Another thing that affected the density of the coke was that they could keep their bed to the same height with 2 cwts. less if they had a suitable coke. He had known some cases where big cupolas were used in which a large saving had been so effected. Of course, they must have with the less dense coke a sufficient non-friability to stand the weight.

Mr. R. Mason wished to ask a question with regard to the statement in Mr. Knowles's paper that the amount of ash present in coke in this country was usually between 5 and 6 per cent. He was rather surprised that it had been put so low. He had with him a number of analyses, made by Mr. Hailstone, of Birmingham, and these gave a percentage of ash, in some cases, more than half as high again. With regard to sheeting the wagons, the one main reason for it was that when the coke was being emptied from the wagon there was a large amount of crushing going on. Coke was easily broken down by its weight when it was wet. With regard to the appearance of coke and the statement that foundrymen were very much in favour of the silvery appearance, he thought it was a very great mistake. His experience of by-product coke was very favourable. He had found it in practice vastly superior to beehive-oven coke. Though he judged coke by appearances, it was not by the appearance of the coke, but by that of the metal, and by the amount of heat required to raise it to the desired temperature. He would ask Mr. Knowles if he had not put the percentage of ash rather too low.

Mr. Swinden said that he was very much interested in the communication from Mr. Jobson which Mr. Knowles had read, with regard to the high sulphur contents of coke. He thought that if this scale from ordinary iron and steel surfaces could be analysed, the result would be very remarkable. The iron seemed to have a most extraordinary characteristic in drawing sulphur from the atmosphere—probably through the oxides. The scale regularly contained 2 per cent. of sulphur, while the iron contained only 0.05 per cent.

Mr. Mather (Middlesbrough) said that they did not get 6 per cent. of ash in any Durham cokes which he used. He would not say that they got remarkably good retort-oven coke from the Durham coal, but it was, at any rate, very much superior to many of the beehive cokes he met for cupola purposes. Mr. Knowles's remarks on moisture reminded him of an article he had read recently, in which it was said that with Westphalian coke containing 10 per cent. of moisture they could manage to use less coke than when they used it dry. They analysed the waste gases from the cupola, and found the percentages CO 10.2 and CO_2 13.3. The coke when analysed gave CO 5.6 per cent. and CO_2 0.65. That was, of course, attributed to the fact that the presence of the moisture kept the amount of CO_2 produced very much lower in the cupola. That was quite possible, and might account for the economy of the coke.

Mr. Surtees (Derby) said that many years ago he made it his business to cube the contents of every truck of coke he could put his hands on for the sake of securing the cheapest possible coke for his foundry. The figures he obtained were a revelation to him because he found that, after all, the cheapest coke as per quotation was, as a matter of practice, very often the dearest. The matter of specific gravity was very important, and he thought that if their foundrymen would be more careful to ascertain the density, the specific gravity, money would be saved

which was often now wasted. A foundryman taking a piece of coke in his hand might say that it was good heavy coke, but as a matter of fact it was not the heaviest coke which would bear the biggest burden. That depended altogether on the chemical contents. He would like to impress on all foundrymen the importance of seeing that they got a good coke with a low specific gravity, together with a good density.

Mr. E. L. Rhead (Manchester School of Technology) said that, with regard to ash in coke, a good deal of the coke sold in the North totalled more than 10 per cent. ash, and he had had under examination material containing as much as 14 per cent. He thought he could point to more than one maker to-day who was turning out coke with not less than 10 per cent., and varying up to 15 per cent. Now, in view of the fact that 6 per cent. had been quoted as a comparatively high figure, he thought it should be known to all foundrymen, so that they might keep a watch on the amount of ash their coke contained. With regard to the effect of moisture in the coke in producing better results, some explanation perhaps might be found in the fact that the presence of the moisture had a retarding effect on the heating of the coke, and consequently would keep the temperature, until it got somewhat lower down in the cupola, below that which ordinarily attained. Moisture when in contact with heated coke would produce carbon mon-oxide at high temperatures, and carbon di-oxide at lower temperatures. But the question of the quantity of carbon mon-oxide or carbon di-oxide that appeared in cupola gases would not necessarily solve the question as to whether they got better combustion or not, so that only, he thought, on the practical results obtained in the burning of such cokes would it be possible to determine whether water in coke was a help or a hindrance. That was an example of the points that might be usefully taken up by their Association as a question of research on the lines referred to by their President in his opening address. The question of sulphur in coke was another point. So far as sulphur in melting was concerned, contact was necessary to introduce it into the iron. In steel-making the conditions were different, and the sulphur got fixed from the gases by contact with the oxides present on the iron surfaces with which it came in contact. He believed that problem arose four or five years ago in connection with reducing a quantity of scrap. The oxide formed upon it in the earlier stages of melting, and led to a considerable fixing of sulphur in the form of dioxide from the gases. (Applause.)

Mr. Dowding (Weymouth) related an experience with coke shipped and used under very dry conditions, which proved to him that a certain amount of water was beneficial to the coke for cupola purposes; that coke with a certain amount of moisture was better than coke absolutely dry. Mr. Knowles had told them, with reference to Swedish iron and Swedish scrap, that he had occasion to analyse and take photographs of two pieces, and found distinct traces of sulphur shown on the surface of one piece. Was that oxide from the rust of the iron, or from the coke that was used in the manufacture of steel?

Mr. Knowles, replying, said that the various gentlemen who had taken part in the discussion, had one answered the other, until there was little, if anything, for him to answer. (Laughter.) He would like to say to Mr. Pilkington, who suggested that the specimen of coke in question was a freak, that the sample was taken from a fairly large piece of coke, and was shown to them just as it was when broken off. With reference to the percentage of ash, he had taken a sort of bird's-eye view of a large number of analyses, and the figures he gave were the outside figures. He had the analyses of four of the cokes on the table. The highest percentage of ash was 6.63, and the lowest 3.12, and three of these cokes were foundry cokes. It might be that in the Midlands, and in Sheffield (the hub of the steel world) they did get lower percentages of ash than up in the North. He did not quite understand Mr. Rhead's conclusion that the increase in sulphur in melting under crucible conditions would bear any direct relation to the surface exposed to oxidation during the melting——

Mr. Rhead:—Perhaps you noticed that I did not hear your paper, and I have not had an opportunity of reading it. Consequently, if it was crucible steel you were referring to, my remarks do not apply. I thought it was ordinary steel melting. I took my cue from the remarks made by the other gentlemen.

Mr. Knowles: I was at a loss to know how that could be the case in an enclosed crucible in a reducing atmosphere. I have been told that I have charged the practical man unduly with prejudice. I have tried in the paper not to seem to dictate. I have now had twenty year's experience in technical education, and as one grows older he becomes far less confident. I *knew* a great deal more when I had the honour of assisting in the technical education of your President than I do to-day. (Laughter and applause.)

Cupola Slags.

Mr. Thos. Swinden, B.Met., Carnegie Scholar, then brought forward, in summary, his paper on "Cupola Slags." (See page 477.)

The President, in declaring the paper open to discussion, said that Mr. Swinden was known to most of them as an extremely careful worker. The paper opened out a subject of very keen interest to all foundrymen, one which, as far as he knew, had not been touched upon at all previously.

Mr. Mather (Middlesbrough) said that the paper was specially interesting to him, because he also had taken a few analyses of cupola slag, and he found there was one striking difference between his results and Mr. Swinden's. In Mr. Swinden's analyses the ferrous oxide seemed to have reached somewhere about 15 per cent. That seemed to him a very high figure, and to mean a considerable loss of iron in the cupola. Of a number of slags which he had analysed and which were produced by melting ordinary Cleveland iron, the mean content of FeO was only about 5 per cent. The slags were of fairly constant composition, and their other constituents averaged 47 per cent. SiO_2, 15 per cent. Al_2C_3, 28 per cent. CaO, and 1.4 per cent. MnO. It was interesting to note that such a slag was a sesquisilicate, having a silicate grade 1.49, like slags II. and III. in Table V., which it most nearly resembled in physical properties. The slag was glossy, with a brownish black colour in the surface when cooled in thin layers, and a dull greenish brown streak.

Mr. R. Buchanan referred to Mr. Swinden's statement that excess of lime also meant excess of iron in slag, and said that he had no doubt it was true because it was founded upon investigation. But his own impression was that the more lime they got into the slag, the better chance there was of having a low content of iron. He had had a number of analyses of slag made, and he could derive no deduction with regard to the iron content from the percentage of lime present. With a small percentage of lime, he had a low percentage of iron oxide, and sometimes with a low percentage of lime he got a

high percentage of iron oxides, so that he could come to no conclusion with regard to the relationship between the content of lime and the content of iron, and could not put the matter on a satisfactory scientific basis. He thought the content of oxide of iron in the slag would also be conditioned by another matter than what they expected as going into the slag, and that was that they were oxidising their iron by excess of blast. He thought they would probably find that excess of oxide of iron in the slag was not due to the excess of lime, but was due altogether to different causes. He only mentioned that point as probably invalidating in some degree the results that they might get by taking the slags solely on their chemical constitution.

Mr. F. J. Cook thought that probably the majority of members present did not have chemical analyses taken of their slags. All that the paper pointed out was clear to those who understood that sort of thing, but if Mr. Swinden would say a few words in his reply telling the practical man the colour of the slag which was best to aim at to get good practical results, and how to get the black and grey, and so on, it would be of considerable service to many present in their ordinary cupola work.

Mr. R. Mason said that he would have liked Mr. Swinden to have told them more definitely what would be the suitable amount of limestone to add to the cupola to get the best results in economical working. The paper required a good deal of digesting for the majority of them, but no doubt they would get more out of it when they had had an opportunity of digesting it. He was inclined to hold for more limestone being used. He considered that always too little was used. He believed that the reasonable amount was 39¼ lbs. per ton of iron melted, and that people often made a mistake in using from 20 to 28 lbs.

Mr. Penlington was very pleased that Mr. Cook had mentioned foundry slag, because, as a practical foundryman, he thought that was a thing which would tell them more than a good many scientific statements which they were unable to appreciate. The slag was the very first thing he (the speaker) looked at every morning as he passed the cupola on his way to the office. The slag told him what kind of melting there had been the night before, even if he had been away.

Mr. Swinden, in his reply, said that with regard to Mr. Mather's remarks about lower iron contents, he supposed it always depended on the conditions existing in the cupola, such as the blast pressure, composition of the iron, and so forth; but the results he had presented were simply the actual analyses of the samples they saw, and the ferrous oxide was certainly high. He supposed there would be no chance of getting ferric oxide. He was very glad to hear Mr. Buchanan speak of the analysis of slag in regard to lime content. If they examined the analyses he had given them, they would find that there was no definite relationship between the lime and the iron, and in the case of No. 3, the slag giving a high iron content, although there was double the normal quantity of limestone, the lime left in the slag was the lowest of the three. What he meant them to understand was that the lime brought the iron out of the slag. The slag came out black, with the lime added in excess, and the black colour was due to the iron chiefly. The whole question of the colour of slags, as he mentioned at the conclusion of the paper, was an extremely interesting one, and he had there a collection of slags just showing the difference in colour. There was a grass green colour due to iron, and a yellow-green due to manganese; but the whole question was extremely complex, and he did not profess to understand it fully. There was no published matter laying down what was the composition of a slag according to its colour. There was a medium slag in each case to be taken as a guide for a normal working slag. In any case, to the cupola tenter the slag was controlled by its physical properties more than by its composition. Its appearance in running from the tap hole might be of more importance than its appearance when it was set. The chief fact was, as far as those experiments showed, that if more lime had been used in the ordinary cupola with silica lining, then the black or the dark green colour was due to more iron in the slag. This meant, of course, loss to the ironfounder. The brown colour was due to manganese. He was afraid that most of his replies had been negative, and would be thought of a somewhat unsatisfactory character, but it was quite impossible to lay down a definite colour for the best slag, when they thought of all the different practices in existence to produce slags. What might be good in one case, might not be good in another. They had to reckon with the peculiarities of each distinct practice. The real colour or "streak" of the slag was ascertained from its powder, and the colour given by the powder was a much better index than the reflected colour in the lumps.

The Convention then adjourned for luncheon, and afterwards practically the whole of the members took part in the visit to the Lancashire & Yorkshire Locomotive Works at Horwich.

Wednesday's Proceedings.

The reading and discussion of papers was continued at the Municipal School of Technology, on Wednesday August 3, when Mr. Percy Longmuir (the President), again occupied the chair. Mr. R. Mason (Leicester) read his paper on "The Cupola," illustrating it with blackboard diagrams. (For this paper see page 474.)

Mr. W. E. Noon (Halifax) enquired about what size limestone should be broken for a cupola of 48 in. in diameter, dealing with about ten tons?

Mr. R. Buchanan (Birmingham), said he had naturally been interested in Mr. Mason's paper. He had brought before them certain views which no doubt were well worth consideration. It had occurred to him during the previous discussion on slags, and the same idea had occurred to him that morning, that the question of the amount of limestone was one of great practical importance, although it was quite certain that no man could give definite quantities to be used at various times. The reason was obvious.

With regard to Mr. Mason's criticism of the continuous tuyere, or the tuyere continued right round the cupola, as it was in a certain type with which they were all familiar, his own mind was tending towards that as the best type which was before them at the present time. He did not say that he had arrived at that conclusion, but his tendency was towards considering it in that light. With regard to the interiors and linings of cupolas, he was pretty certain they had not yet reached the final form that the interiors of cupolas were going to take. (Hear, hear.) He sometimes wondered why they built up that hollow space which was worn away within a week. It was rather significant that the modern blast furnace was largely built on the lines of avoiding those places or areas in the inside of the furnace. The blast furnace was much more durable than the cupola, and they might hope some day to arrive at the true cupola, which would go on melting as long as possible for a very considerable period, with a very small quantity of repairs. They were aware that the blast

furnace would run for seven years and never be repaired, whereas they had to repair cupolas practically every day, and very considerably every week. It was perfectly obvious that they had not arrived at the final contours of interior linings. Harking back to the slag question, he had been carrying out a recommendation which Mr. Keep made a year or two ago as regards the separation of the fluid slag of the cupola from the final dump of coke, and the remaining iron which they got at the end of the flux. He adopted that recommendation for leaving the fluid slag at the tap-hole, and he found it resulted in what Mr. Keep said was a considerable saving, in so far that hand-picking was avoided. They broke it and did away with what had been fluid slag, putting back on the final charge what came out from the tap-hole on the other side. When they considered the amount of time spent in picking over the slag which was originally fluid, from the coke which had been burnt, he thought they would find there was a considerable saving. Under the old system they had no certainty that there was no unburnt coke or iron or waste going to the tip. With regard to Mr. Mason's centre column of coke, he should consider that was only feasible in a cupola of considerable diameter. It was not applicable to cupolas of 2 ft. or under. After all, when the charge had been covered up by the succeeding one and was sliding down the cupola, it required a very clear mental vision to see what was happening. He thought most of the cupolas in use were very fine in the linings, so that no scrap or pig-iron ever caught on or got tipped up, and the iron generally progressed downwards in quite a regular fashion, as when last seen in the charge-hole. The point Mr. Mason mentioned was probably well worth trying. Personally, he had not done so, but had always spread the coke over the iron. He thought, however, he had not been using cupolas so large as Mr. Mason had been using. But he could say that his own practice was not particularly indifferent although perhaps no so well regulated as Mr. Mason's.

Mr. F. J. Cook said he quite agreed with Mr. Mason's view as to the shape of the tuyeres. Personally, he liked to have his tuyeres dipping down somewhat and not square as shown on the drawing. If a man was melting a ten-ton lot per hour, he did not care how careful that operative might be, he was apt to be worried at some time or other and get the slag on the top of him before he was aware of it. It might be said that ought never to happen, but unfortunately he had known it happen, and he had known cases where trouble had been saved by the fact that the man had had a little warning at a busy time, and the arrangement had been found useful. In regard to air, there should be as little restriction as possible from the blower to the air belt. Anyone who had to do with compressed air, with a small diameter of cupola, could only get the best results and at the same time the least expenditure of energy, by securing the least possible resistance to the flow of air. Therefore, anything that could be done in the way of shortening the bends or doing away with the bends by using pipes from the blower, and thus securing a free current of air, was a desirable thing. Another question was the area of the tuyeres. He had taken out the areas wherever he had been able to get any, amounting to some hundreds of cases, where cupolas were giving the best results, and he found in all cases that the best results had been obtained where the tuyere area was from one-twelfth to one-sixteenth of the area of the tuyere zone. He was rather afraid Mr. Mason's remarks might be taken as disparaging blast gauges, although he thought that was not the intention. Personally, he considered there was a great advantage in employing the blast gauge for taking records. Unless they obtained the correct blast they could not know how they were working. In particular, when they were working an electrically-driven motor, the absence of a blast-pressure gauge might give enormous trouble. He might give an experience in the production of cylinder iron. At about five o'clock in the day the blower which was driven by an electric motor varied considerably. The plant for generating electricity was up to its peak load, just about five o'clock in the afternoon, when all the lighting required in the works, and which had been up to its full voltage, dropped considerably. Consequently, the voltage on the blower went up at once, and unless they had a blast-pressure gauge, they might have, without knowing it, double the pressure of blast. Although the charges were carefully weighed, they found that the iron sometimes came so hard that it could not be machined. That furnished a very good reason why they should use the blast gauge to ascertain the pressure. It was absolutely necessary, when they were making cylinders, to be able to regulate the blast. At the works where he was employed, they regularly measured the blast with a view to getting certain definite results. It was the practice to analyse the iron and the coke, and to weigh in everything in exact quantities; yet they found that unless they regulated the blast pressure, they got considerable variety of results. They were in the habit of taking hardness tests every day, and they found that the iron varied; it was possible with certain variations, by increasing the pressure, to get the same results. After eight or nine years work in that way, the foundry was able to produce castings for cylinders absolutely to their requirements for hardness, strength, etc., and that seemed to suggest that there was something to be said for blast presure gauges. For ordinary castings there was not the same necessity for a gauge, but where motor cylinders and steam cylinders were being made, and the best results were essential, they could not do without a blast pressure gauge.

Mr. Macfarlane (Horsehay) said that many of the points advocated he could support from his own experience. For example, the increasing of the area of the tuyeres, and the reducing of the blast pressure were practices he had found beneficial, and, in particular, they promoted economy. He would like, however, to ask one or two questions. He had found it economical to introduce air above the melting point, while it assisted to bring down the iron more quickly with less coke; but he would like to know what was the best pressure gauge to use, and also the best position at which it should be placed. In regard to the making of tuyeres in the 36-in. cupola, would Mr. Mason suggest having the tuyeres in the same manner at the bottom and at the top of a 36-in. cupola.

Mr. Alfred Sixsmith (Carron) inquired what effect would arise from irregular blast in the working of a cupola. For example, he might have a beam engine of the old fashioned type, with a big stroke producing blast, so that possibly at the end of each stroke, a slight deficiency of blast might occur.

Mr. F. J. Cook (Birmingham) said he would like to add one other word. He quite agreed with Mr. Mason that it was dangerous for any man to say that a certain blast pressure was necessary and effective to produce certain results, and that opinion ought to be emphasised. He had two cupolas of exactly the same size in the tuyure, yet, for some reason or other, he found it necessary to use a different blast pressure in the two cupolas to get the same results. They must not suppose that a 24-oz. blast pressure would inevitably produce a certain result. That would depend mainly on the cupola.

Mr. W. Jewson (Dereham) enquired if Mr. Mason could tell them the advantages of employing the upper row of tuyeres. He had cupolas equipped in that way, and he would very much like to know the best time for using the upper tuyeres, and when to shut them off.

Mr. Penlington (Manchester) desired Mr. Mason's ideas on the different methods of fluxing. Should they flux over the charge, or should they put about three or four tons on before commencing to flux? Those were two distinct methods employed, the relative merits of which he would like to know. He was interested also in various patent fluxes on the market. Was there any advantage in employing them as compared with limestone, provided they were used in a proper manner? He was very much interested also in the shape of the cupola. He understood that the reason the cupola was repaired in the melting zone where it was burnt was, more especially, to save the coke charge. After using a furnace for a few months they found that the area was much larger than when it was new lined. They had to keep the area of the bed charge at a given height, and they must use a larger percentage of coke in that bed charge. That made against the operator in the total consumption of coke. Did Mr. Mason agree that that was the reason for the repairs?

Mr. Hatfield (Sheffield) considered that if to the table he had given, Mr. Mason had added other figures, showing probable blast pressure in relation to coke consumption, it would have been additionally interesting. In regard to that question of blast pressure, he thought the figures given were on the right lines. Those high pressures had been used, but he was quite sure they were largely unnecessary. Having obtained the correct volume in relation to the proper amount of coke, they would get the best results. With regard to the shape of the cupola he considered Mr. Mason was wrong in his preference for a cupola with the wide bulge, and he had no doubt that Mr. Buchanan was correct in his remarks as to the ultimate shape. The idea was to get the heat out as quickly as possible and to bring it on to the iron. He thought if they had a cupola narrower at the top, although not narrowing it much below the charge door they would get the best results.

Mr. Smith (Chesterfield) remarked that he was not greatly in favour of two rows of tuyeres, and that was connected with the further question as to what was really the melting zone in the cupola, and he did not think anyone could definitely specify that. They could only be guided by the experience inside the lining, which gave a very fair indication of the melting zone. With cupolas which he had known give great satisfaction, the tuyeres were rectangular, with semi-circular ends and of the size of 9 in. by 5 in. To some extent that approximated to the practice of having two tuyeres going round the cupola. At the same time, he held that if they could get a continuous tuyere area round the cupola, they would get better results than ever. Then the air would get thoroughly circulated right through the cupola. He was not sure whether that idea had been advanced, but so far as he knew it had never been put into practice. It seemed to him it would secure thoroughly economical melting.

Mr. Mason, replying, said the discussion had been very interesting, though he thought it would have brought out more points, because he gave them plenty of ground for disagreement. As to the size to which the limestone should be broken before going into a cupola of 48 in., he thought that the stone should be broken to the same size for all diameters of cupola. The sellers of limestone generally broke it into splinters of about 1½ in. long by ¾ in. thick. That appeared to be the best size, and though the matter was rather different when the foundryman had to break his own limestone, it should not be larger than an ordinary hen's egg. He quite agreed with Mr. Buchanan that it was impossible to give the precise amount of limestone to be used, but he was certain the usual practice was to use too little, and he also thought they should avoid coke which produced 20 lbs. per ton of limestone ash. Naturally, they did not wish when buying coke to pay for limestone. With regard to the continuous tuyere, Mr. Buchanan appeared to favour that form as the best, and he believed Mr. Buchanan had spoken before in favour of the Mackenzie cupola, which had a continuous tuyere. It was sometimes called a one-hour cupola, but it was impossible to keep the cupola clear on that basis of working. The continuous tuyeres would not give sufficient space if they employed an adequate quantity of limestone. Mr. Buchanan disagreed with him as to the centre coke column on the ground that it would not do in a 24-in. cupola, but he had personally seen it employed in a cupola of that size, and it gave good results, particularly in a small cupola melting seven tons at a blow. But it was possible they were measuring their cupolas differently. He was measuring his 24 in. at the tuyere area, while others measured at the charging hole. One, of course, would give a considerably larger area than the other. He agreed with Mr Cook in his preference for the dipping of tuyeres inside. It was a good practice to make them point downwards slightly, because they got some of the iron or slag trickling in occasionally, and it was convenient to be able to chip it out, which was an important matter. As to Mr. Cook's further request for the areas of the tuyeres, he had given them in conjunction with the blower. He was interested in Mr. Cook's remarks on the blast gauge, which was found so necessary with the motor-driven blower. That entirely supported his own view that they should know what the cupola was doing day by day and hour by hour. It was necessary to know at three o'clock and at four o'clock what the blower was doing. They wanted to know exactly whether they were getting the same amount of wind. As to Mr. Macfarlane's enquiry on the introducing of the air above the heat zone, they had seen a description of a cupola showing the air coming in from the top and also showing its entrance through a pipe about a foot high. At the works where he was engaged they had an arrangement of that sort before he went there, and the system was advocated as something very useful, but personally he found no advantage. The air entered high up, and they found that at the point of entry a little bit of the nose had gone, and there were various points showing oxidised iron. They never discovered that they could use less coke or derived any other advantage. Therefore, they shut off the tuyeres, although the pipes were still there. With regard to the enquiry as to the best gauge to use, he did not think a record gauge was of any advantage, except to tell what the cupola was doing. He applied a bit of glass tube and fastened it on the side of the cupola and found that was quite an effective record glass gauge. As to Mr. Hatfield's suggestion that the bringing in of air at the top was an advantage, he had found that it was a disadvantage from the point of view of economical melting to allow too much blast below. The idea was to let all the materials get the full advantage of the heat, and to get the iron into the hottest positions. An enquiry had been made by Mr. Sixsmith as to the effect of intermittent blast pressure. The effect would obviously be to get slower melting, because the cupola would not be so hot. The idea was to get a regular blast pressure rather than an intermittent, obtaining it nearly always uniform. Then they got the best results and the

most economical melting. With regard to Mr. Jewson's enquiry, as to the advantage of the upper row of tuyeres and the best time to open them and shut them off, his idea of the advantage was that the air coming in at the tuyeres formed certain gases which combined with another mixture of air, and so those gases were consumed at a higher point in the cupola. That was better than getting all the cold air entering in too small a space. Obviously, if they sent in a large volume of cold air that part of the furnace would have a considerably lower temperature. If they sent that air in at different points of the cupola, the air was broken up more effectually, and warmed in a better way before it reached the point where combustion took place. A question had been asked by Mr. Penlington with regard to fluxing. He (Mr. Mason) thought it was better to introduce the flux with each charge, because it operated more effectually. There was a point with regard to small charges. In such cases, they did not get much flame at the charging hole, and they secured that the flux would be put on at the proper time so as to come in touch with the sand, and it did not touch the cupola walls before commencing to operate. Patent fluxes had been referred to. Most of them were made up of fluorspar, which was undoubtedly good for making a fluid slag, but it was expensive to use, and he considered that a sufficient supply of limestone was just as good. In America, a great deal of those patent fluxes were used, but he understood that the employment of fluorspar was made a ground of complaint by the men working at the shops, on account of the offensive gas which was given off, and which very much annoyed them. It was said that occasionally it had caused a strike. They read sometimes of American cupolas being troubled with foaming slag. He was told by an American that in one case it came right out at the charge door. He would not believe him, only he had seen something about it in the papers. (Laughter and "Yankee.") With regard to the repairing of the lining, the idea was, of course, to keep the cupola at the proper shape for economical melting. That was difficult, because it was always burning away and required a lot of fettling up.

Theory Underlying Malleableising.

The next Paper was by Mr. W. H. Hatfield, B.Met. (Sheffield), on "Theory Underlying Malleableising." A brief summary was given by Mr. Hatfield, and the CHAIRMAN, in introducing the lecturer, said the Paper might be taken as representing a summary of many years really hard and strenuous research.

MR. F. K. KNOWLES, B.Met. (Sheffield), congratulated Mr. Hatfield on his Paper. It occurred to him as remarkable was the great secrecy that the scientific man and the practical man maintained in regard to that class of work. It was said that to have the best work they required theory and scientific training. Why did not Mr. Hatfield tell them more than he had done, as to how he obtained certain tests? It would take him not more than two minutes to do so, and they would all have been delighted to waste that amount of time. When he had enquired about methods of making malleable iron, one man talked to him of using shovelfuls of material, another talked about handfuls, but they never got any farther. Why did not Mr. Hatfield give them some samples? He would gladly come to Manchester purposely to obtain them. He had not previously heard Mr. Hatfield lecture, but he would promise him that when he got back to Sheffield he would talk to him, and see if he could squeeze some of those things out of him. They had heard a great deal about the perfect equipment of Mr. Hatfield's works, but he could promise them that much as he loved that Association they would not have an invitation to visit those beautiful works. (Laughter and applause.)

MR. MATTHEWS (Walsall) remarked that they took it as a general rule that, during the annealing process, there was a contraction going on. He found in many of the engineering papers and in the foundry Press of America an increase was spoken of. He would like to know whether that was to some extent due to the separation of the carbon, which caused the volume to increase. He did not mean by that in the form of free carbon, but as temper carbon. He took it that was the reason why American people spoke of expansion and increased volume. In reference to the separation spoken of by Mr. Hatfield, he had had one or two interesting problems during the past week or two, and he had brought with him some samples, which he would be very pleased to show to Mr. Hatfield, with a view to that gentleman, if he thought proper, referring to them in his answer. Mr. Hatfield had said that the carbon should not be separated out into the free state, and with that he entirely agreed. He would call his attention to two samples, one of which was a piece of pig-iron from which the other article was cast, and there was a certain amount of free carbon which should not have been there. In the annealed specimen the casting was quite soft. He took it that those particles of carbon isolated every particle of iron, which caused it to become rotten, and so to readily break up. He understood that the reason for that might be, first, the silicon probably being rather high. According to Mr. Hatfield's analysis and also that given in the Swedish Paper, the silicon was 0.2, which was rather high for malleable iron. Then the manganese was rather low. He had intended to have treated that iron with ferro-manganese added, so as to see the effect. He took it the manganese would cause the carbon to be held in solution, and if the annealing process was prolonged the free carbon would be shown. Another cause of defect might be that the annealing process had been carried too far. Personally, he was in doubt about that. He considered the iron was too soft, owing to the excess of silicon or the small amount of manganese present. In some of their castings they had had a dark iron with a small skin one-third of an inch round outside, and in some samples of cycle work where the outer skin peeled off, there was a darker skin in the centre. His contention was that the annealing had been rushed too quickly, and the skin of iron formed on the outside had been practically burnt on. The skin in the centre of the section was quite distinct. He noticed that in the Swedish Paper it was stated that the practice was to anneal in the ovens for a shorter period than in England.

MR. R. MASON (Leicester) hardly considered it quite fair on the part of Mr. Knowles to try to drag from Mr. Hatfield his secrets of manufacture. They, as foundrymen, had got to be guarded in that matter. He presumed nearly all of them used malleable iron castings at some time or other, although his firm did not manufacture them, preferring to buy them. But it was a common difficulty in making a pattern to know how much contraction should be allowed for. One authority stated the allowance should be a quarter of an inch to the foot, while another would suggest one-eighth of an inch. He would like to know what ought to be allowed as between the casting and the pattern.

MR. R BUCHANAN said he would like to ask a question with regard to the analyses, in respect of which there were some important differences. The principal differences appeared to be in the sulphur. For example, in the Reamur iron the sulphur was 0.35 per cent. The question was whether it was possible to have good material, with such an amount of sul-

phur in the malleable casting. He noticed that in the Black Heart process, the amount of sulphur given was 0.06 per cent., so they had that great difference as between 0.35 per cent. and 0.06 per cent. In regard to silicon, in the Reaumur iron it was 0.50 per cent., and in the Black Heart 1.10 per cent., or about twice the amount. With regard to manganese, in the Reaumur it was only a trace, whereas in the Black Heart it was 0.14 per cent., which was certainly not a great amount, but still decidedly different. He would like to know what really accounted for those differences. The differences in silicon and sulphur were essential differences between the two qualities of castings. Owing to the short time required for annealing the Black Heart, it appeared that that would be the simpler process to work. He was unable to say whether the irons were of different values. The experiments anyway pointed to greater simplicity.

Mr. F. J. Cook (Birmingham) enquired as to the nature of the essential test. He understood that tensile tests were nearly the same, but he would like to know whether they were shock tests, tension, or bending tests?

Mr. Hatfield, replying on the discussion, said that he would like to thank Mr. Knowles for his kind remarks, which he specialy appreciated, because he happened to be one of Mr. Knowles's old pupils. Anything Mr. Knowles wanted to know he should be pleased to tell him after the lecture. Mr. Matthews had brought out several points. With regard to the query as to contraction in malleable cast iron, the patternmaker in the malleable foundry would tell him it had taken him all his life to find out, and it was impossible to come to a detailed conclusion. He should say that if a light malleable casting showed a steely fracture, the expansion would be about a quarter of an inch to the foot; but with a heavy casting the case would be very different. In the case of the Black Heart process, they had very different materials altogether. With a Black Heart casting the contraction in the hard state was about a quarter of an inch. They might reckon for annealing purposes upon a difference of practically half the distance between the original size of the casting and the pattern. In other words, if they halved the difference between the pattern and the casting, they would about hit the Black Heart shrinkage, but that was merely a broad principle. With regard to the skin referred to by Mr. Matthews, most malleable iron-founders had experienced that at one time or another. Probably, if he employed a good pyrometer, and took care that the metal was not over-annealed he would not be troubled with the skin. It was a question of over-annealing, and applying too much heat. As to the influence of silicon and sulphur referred to by Mr. Buchanan, he would be very glad to go into that matter, but he was limited as to time, and would want 24 hours to go through the subject properly. He had before him one or two samples, both of Reaumur and of Black Heart. They included a white fracture of Reaumur iron. It contained a little carbon in combination with pearlite. The appearance of the fracture suggested that there was about 0.5 per cent. of combined carbon, which he believed was attributable to the presence of sulphur. Figures had been shown exhibiting the different characters of the carbon. With regard to the tensile test in the Black Heart they got 20 to 25 tons, and on the average an elongation of as much as 19 per cent., but he should put it at 10 per cent. to 15 per cent. The Admiralty requirement of Black Heart was 90 degrees, which they could get with Reaumur, and they would get a maximum stress of 20 to 25 tons. With regard to elongation, if they got 5 per cent. or 6 per cent. they were doing well. Generally speaking, they would not get anything like the bend with the Reaumur process that they would get with the Black Heart. The reason was evident from the micrographs. In the Black Heart they had ferrite which was practically pure iron, comparing, therefore, with wrought iron, whereas the Reaumur, having carbon in combination, was similar to steel. They, therefore, got that difference in the result. The Black Heart would give the better test under shock, but it would not do to recommend one before another. For all mechanical properties the Black Heart was the best except for wearing, but when it was a case of resisting compression probably they would find the Reaumur giving the best results.

The Chairman remarked that considering Mr. Hatfield represented a malleable firm, he had given them a good deal of information.

The Electric Furnace.

The Paper by Mr. W. S. Gifford, A.R.S.M., on "The Electric Furnace," was read in abstract.

The Chairman, in introducing Mr. Gifford, remarked that some members of the Council, when the subject of the electric furnace was mentioned, thought it was probably too theoretical. To his own mind, there was no subject that the practical man, and particularly the practical founder, required to give more attention to than that of electrical smelting. There were hundreds of tons of steel castings coming into this country week by week, melted from electrical Continental steel, and there were foundries which had proved a success using wholly electrical heat for melting. In view of that fact it seemed to him most advisable that they as an Association should begin to look into that question of the electrical furnace, and whether they might not have to go much further the future would show. It was quite likely that many of them would have to take charge of those plants.

After the reading of the Paper,

The Chairman, in opening the discussion, said that the advocates of the electrical furnace generally spoke of the purity of the product obtained, and they quoted figures showing much smaller quantities than usual in the way of sulphur and phosphorus. But Mr. Gifford had set forth that analysis was not the only advantage. The great point was that the steel was able to be finished in the ordinary electric furnace in an atmosphere from which oxygen was absent. For years, oxygen had been the common enemy of most of them. It seemed to him the greatest advantage was the oxygen-free atmosphere.

Mr. F. J. Cook (Birmingham) said he could conceive the possibility of the electric furnace carrying with it a very great advantage, especially for such things as cylinders, but the question was one of price. He would like to know whether Mr. Gifford knew of any works producing grey iron by means of the furnace. It might be very valuable in the case of steel for superheated steam cylinders, but he would be glad to know of its use in the iron foundry.

Mr. Hatfield (Sheffield) said the electrical furnace offered considerable advantage as compared with the heating of iron in the cupola. In charging the cupola they put in iron, coke, limestone, and it all went down together "higgledy-piggledy." In the electrical furnace, they had the advantage of perfectly clean smelting. But the real question was that of cost. Looked at from the commercial standpoint, he was afraid the cost would exclude for their purposes the introduction of the electric furnace. He would like to know whether Mr. Gifford had any experience of the cost of melting for foundry purposes, either cast iron or white irons, and the actual cost per ton for melting which could be expressed in terms comparable with what was done in their own works? They all recognised the advan-

tage of electrical smelting as being an admirable thing, but the desirable thing was to bring it down within the reach of manufacturers. No doubt, the electrical furnace was cheaper than the crucible, but beautiful steel was being made in the open-hearth furnace, which was very much cheaper than the crucible. According to what his friends told him who were employing the electrical furnace, they could produce excellent material from it which, while being cheaper than that of the crucible, was more expensive than open-hearth or Bessemer steel. Academically, the value of the electric furnace had been proved, and no doubt when steel could be produced at a very low figure they would all be there.

Mr. R. Buchanan said that one question was suggested by the remark, "A short refining process in the electric furnace may often be adopted advantageously, more for removing the gases and consequently increasing the fluidity than for obtaining extreme purity of chemical analysis." He would like to know how was it possible to eliminate the gases while increasing the fluidity?

Mr. F. K. Knowles (Sheffield) said he had heard a large number of Papers and lectures on the electric furnace, dealing with various electrical furnaces. It was a strange thing to him that whoever read a Paper or delivered a lecture, adopted the method of asserting that the furnace was capable of making steel of such a character as had never before been known. That was a great mistake. The greatest recommendation of the Héroult furnace was that several of them were being put down at the present moment. Whoever might be responsible for securing those orders, the facts, as stated in that Paper, had not weighed one iota with Sheffield manufacturers, because they had made steel of as great purity as ever would be made in the electric furnace, and had done it at much less cost. It was very well to tell them that it would be used by the metallurgist. No doubt he would take advantage of the work of the electrical engineers to arrive at his own object, but the electrical engineer was not needed to teach the Sheffield manufacturers how to make steel. They had been making steels for many years by the open-hearth and Bessemer process, and even the Tropenas process patent had now run out. They could not have a better furnace for producing pure iron. It would be a good thing if each man would stick to his last. It was when the cobbler began to put a patch on somebody's trousers that he got wrong. (Laughter.) He would like to know what were the particular gases which the electrical furnace could remove which the steelmaker could not get rid of by other means. If they could show them how to get every particle of impurity out of their steel, they would do them a very great favour, and the time might come, which had already been anticipated at that Conference, when they would never have wasters at the foundry.

Mr. Campbell (London) remarked that several speakers had compared the electric furnace with the open-hearth furnace. He had an impression that manufacturers were not quite satisfied with the work they got from the Siemens furnace for small castings, and it was in the case of those small castings that it had been found advantageous to put up the electric furnace as a kind of adjunct to the larger plant. At the present time, there were four large steel foundries putting them up, and there must be some reason, because the manufacturers adopting them had all been on the Continent, and had studied the subject at places where the furnaces were in operation. One matter to be taken into consideration was the favourable load factor when the furnace was running for 24 hours each day. In the case of one small foundry, the gas engine would be used to generate power, which would probably cost 0.3d. to 0.4d. per kilowatt-hour. Under those conditions, it must be much cheaper than the crucible process. He had not noticed any statement in the Paper that the furnace was going to improve crucible steel. If small castings made from a Siemens furnace could be made with a small proportion of wasters, and the output of the furnace increased to a certain extent by the use of electric refining, that was enough to cover the cost. In the case of a Talbot furnace, the expense was largely due to the desulphurising process, and if that was unnecessary, the Talbot furnace output could be largely increased, and in that case the expense of electric refining would probably be more than recovered.

Mr. Gifford remarked that, as regarded grey iron, that Paper related to simply steel castings; but so far as he knew he did not think that any furnaces had been erected for grey iron.

Mr. Campbell (London) said he was not aware that the electric furnace was being used commercially for making the castings of the kind described. At present it was not a commercial proposition. He was unaware that anything was now being done in connection with the malleable trade, but the electric furnace had been adopted largely by people manufacturing aluminium ferro-alloys, ferro-chromium, ferro-silicon, and so on. People in the steel trade were now adopting this furnace, and it would be found an excellent improvement. Firms in England and Scotland were putting up more electrical furnaces than any other country. Apparently, they, had been waiting for the foreigners to do all the experimenting, and now they were going ahead themselves. England, in particular was taking the lead. He knew of at least eight furnaces under construction in England at the present time.

Mr. Gifford, replying, said he did not pretend that the electric furnace would necessarily be cheaper than the open-hearth furnace, but simply that it would be cheaper than the crucible. But he did claim that he was quite justified in saying, "The product obtained either by melting cold scrap or refining open-hearth steel is of the quality of good crucible steel, so that the advantage of the electric furnace over the open-hearth is that it produces a superior steel for the same price." It was frequently possible to use cheaper raw materials, and this sometimes more than counterbalanced the cost of the electric furnace. With regard to the paragraph to which Mr. Buchanan had called attention about removing gases and consequently increasing the fluidity, the word "consequently" was a misprint, and that word had been omitted from the final prints of the Paper. The calcium carbides were very noticeable. A man in Sheffield intended to bring some of this slag from the Continent, and got into trouble with the Customs officials, who thought that he was bringing explosives, and all his luggage was searched. Personally, he had found the same trouble in getting it through, or he would have brought some to Birmingham.

Brass Alloys.

Mr. O. F. Hudson, M.Sc., of the University, Birmingham, then read in abstract his Paper on "Brass Alloys"

Mr. Hudson contented himself for the most part in showing and describing a number of remarkably good lantern slides. His exhibitions of coloured prints showing the different constituents were exceptionally fine.

Mr. R. Buchanan (Birmingham) remarked that his question was not relevant to the Paper, but they would be glad to hear from Mr. Hudson something about that non-contraction in brass which was obtained at Bir-

mingham University. If they had a brass which could be readily made, and which could run into patterns without contraction, it would be a very useful thing. He hoped Mr. Hudson was in a position to tell them something about it.

Mr. F. J. Cook (Birmingham) said he only wished to comment on the excellence of Mr. Hudson's photographs. Only those who had had the trouble of trying to get micrographs could appreciate their excellence. The photographs appeared to him the finest he had ever seen in his life.

Mr. Hatfield (Sheffield) congratulated Mr. Hudson on the excellence of the micrographs, and in conclusion suggested that instead of the terms Alpha, Beta, and Gamma, it would have been better to use exact descriptions such as "Austenite."

Mr. Dowding (Fiuma, Hungary) said the subject was one of particular interest to himself, because his own business dealt more particularly with high-pressure bronzes and brasses for military work. With reference to the casting of brass, it frequently happened that he experienced trouble when he was required to produce brasses to resist air and water pressures. He investigated in the best way he could with a microscope, but he was bound to say he found very great difficulty in that respect. He had sometimes obtained a series of eight or ten samples, or even as many as twenty, and had never been able to arrive at exactly the same results in each case. It might possibly be due to his ignorance of the way metal should be treated. But he was egotistical to think it might be due in some measure to those accidental occurrences which happened during the process of melting. They all knew that copper was a very funny thing to handle and where they worked with the crucible, it was a difficult thing to get absolutely reliable brass for their own purposes. He did not know whether it would be possible for the lecturer to give them any idea as to what happened in the case of metal over-heated, or where the zinc was not exactly pure, or where the method of treating the casting in reference to sand was not always alike. Probably in England the caster would easily overcome his troubles.

Mr. Hudson, replying on the discussion, thanked the members for the way in which his Paper had been received. There was not much he was able to tell Mr. Buchanan with reference to the non-contracting brass, which was rather outside the scope of the Paper; and the particular alloy to which he referred was one not dealt with at all in the Paper. It contained far more zinc than any they had yet considered. With regard to his use of the technical terms Alpha, Beta, and Gamma, the great advantage of them was that they were perfectly impersonal, and he considered them rather less cumbersome than some other names applied to those things. Reference had been made to the difficulty of getting the same results every time from the same materials, or substantially the same materials. That merely illustrated the great complexity of the whole subject, and the enormous difficulty in exactly repeating the conditions with regard to casting, purity of metals, and the character of the moulding materials, etc. There was no doubt that all those things, and especially the materials in the metal, had a very great influence on the product. Also, dissolved gases and dissolved oxide had a very important influence. Those had so far been very little considered, and there was a great deal more to be done on that subject

Discussion on Other Papers.

The President said there were still two more Papers, one by Mr. G. A. Blume, of Sweden, whose Paper was on the subject of "Malleable Cast Iron, and How it is Produced in Scandinavia." Mr. Blume had had an accident, and had fractured his leg. He would like them, as an Association, to express their sympathy and he would suggest that they authorise the Secretary to send the following cable to Mr. Blume:—"Deepest sympathy from members. Trust speedy recovery." No doubt they would readily authorise that to be sent. (Applause.) The other Paper was by Mr. Mather (Middlesbrough), on the subject of "Hardness Testing of Cast Iron." It was proposed to take those Papers as read, and they might be discussed as far as time would allow, and question could be answered by correspondence.

Mr. F. J. Cook (Birmingham) said that with regard to the Paper on "Hardness Testing," there was a statement which did not agree with his own facts. It was stated "the hardness of cast iron depends chiefly upon its content of combined carbon, and also on the silicon (regarded independently of its influence on the state of its carbon)." That statement was not correct. Taking the hardness testing by the true method it did not always follow that the metal that had the highest quantity of the hardening element gave the highest results in hardness. The test might be a test of penetration, but that might not be always consistent with the quantity of the hardening elements. In taking iron from the soft state to the hard, they sometimes came to a point where, although they had increased hardness, the density of the metal was not the same and the crystals were large. He had had many instances of testing, having taken something like 8,000 or 9,000 tests, and although the combined carbon and sulphur had been doubled, yet the hardness shown was less. In other cases where that had been attained, the fracture had always shown itself. On one occasion he had adopted the drill test, and he was trying to increase hardness in certain cases. Although he was certain that there were more of the harder constituents present, yet the drill was soft and his attention was called to the matter because they could be so easily machined. The test was not always the true indication of the hardening element present. He had prepared some figures which he would send on for printing in the Proceedings, of actual tests both for analyses and results obtained. It was a question that required to be closely watched to see that they got their density, or the results would be affected.

Mr. Hatfield (Sheffield) said there were some questions he would like to ask Mr. Blume. That question of cast iron was very interesting to him, as it affected malleable iron. The Paper was excellent, and he agreed with most of it, but there was a point where Mr. Blume talked about his experiments with the open-hearth furnace; and in the reverberatory furnace he talked of a fuel consumption of 10 cwt. to the ton. He hoped that Mr. Blume would have an opportunity of replying to his remarks. His impression was that that would be found to differ from American practice. The Paper also said, "I found as the mean result that a 3-ton charge could be changed, melted and tapped in less than two hours—in fact, at one time, these operations only required one and a half-hours." He would like to know first of all what size the furnace was that would melt three tons in that time? Were the three tons melted in a 20-ton furnace or in a 3-ton furnace? Mr. Blume went on to say that, "At one time, a melt of three tons was made with a coal consumption of less than 350 lbs. of coal." That would mean 1 cwt. of coal to a ton of iron. Even with the cupola they could not quite attain to that with coke. He did not know whether that was a mistake, or whether it should read—"3,500 lbs." Then he said, with regard to the pyrometer, that they had all kinds of instruments, but he had never come across a really reliable recorder for works' practice. Personally, he had some which appeared to be giving good results.

MR. SMITH (Chesterfield) remarked that Mr. Cook had raised an important question on which he himself was not clear. As a rule they looked upon combined carbon as leading to hardness, and when it was increased they usually expected the hardness to increase. Mr. Cook said that did not always follow. The tests taken by Mr. Mather in some cases appeared to bear out that, but how that was he did not know. Mr. Cook had referred to density, but if they got a white iron, he did not know whether they would make a distinction between very close iron in respect of density, but they would like some definite idea as to why they should not say that hardness increased as the combined carbon increased. Taking sample 897, it gave 0.34 of combined carbon, with a hardness number of 30. Then, if they took No. 956, it gave a combined carbon of 0.24, with a hardness number of 35, and if they took the sample 1,114, which gave a trace of combined carbon they had a hardness number of 36. In each of those cases, as the combined carbon increased, the hardness number reduced. He would like to know whether that was due to the method employed by Mr. Mather for testing; but he himself was certainly not clear on the point. A good deal might be said about test bars, which had received much attention, and a good many examples could be produced. He had known a case where castings made of the best materials and fully inspected by a fully qualified inspector, and thoroughly tested were rejected because the test bars were not quite up to the mark. The main test in all those castings was the pressure test, but they could not put a pressure test on a test bar. They required deflection, transverse, and tensile tests. Some reason should be given, and those who made the castings should have some consideration. The test should be pressure, and should not be looked at as a final test in the test house. He knew a case lately where castings were inspected in which the inspector said, "We don't want the test bar. We are satisfied with pressure." He called that a spirit of sweet reasonableness. (Laughter and applause.)

This concluded the discussion on the papers, the only remaining business being the votes of thanks to governors of the Institution, the local Reception Committee, and the authors of the various papers, all of which resolutions were heartily carried.

The afternoon was then occupied with the visit to the works of Messrs. Tweedales & Smalley, Castleton.

[NOTE.—Owing to pressure on our space, the report and illustrations of the visits will be held over until the next issue.]

PAPERS READ AT THE CONVENTION.

The Cupola.

By Mr. R. Mason.*

In reading a Paper on the cupola, I hope you realise how difficult it is to say anything new or original about the subject, and as I am only allowed to address you for 10 minutes, all I can do is to give you some particulars from my own experience of what I have observed, and tell how I got results which are considered good, after considerable experience of trial and failure. If I do not speak on the points which you came prepared to discuss, I think our President may allow questions which will be of general interest on this subject and which may arouse more interest and be of more value than the Paper itself.

When installing a cupola, the points which should guide one are—how much it is required to melt each day or each blow; and how many hundredweights or tons of the molten iron can be used per hour. Of course, a shell big enough for future needs must be employed, the lining being built to the diameter necessary for the present requirements. Cupolas of the following diameters, where melting continuously for three or more hours, will melt at an average rate of :—

Inches diameter.	Per hour. Tons.	Cwts.
20	1	5
24	1	17
30	3	0
36	4	5
(not 42 in.) 43	6	1
48	7	10
54	9	1
60	11	15
62	12	11
66	14	15

I am aware that others quite as capable of observing as I am, have given tables which do not agree with this, but I think a good deal of the variation is due to the fact that when the cupola was measured it must have been measured at the tuyeres, and to whether they are stating how much has been measured over the full time of the blow, or only during a certain period. The figures I give are the average per hour during a three or four hours' blow, and the cupola is measured at the largest point to which it burns out the lining—between the tuyeres and 4 ft. higher up—and I consider that is the right place to measure to get the nearest comparative results.

In answer to the question, should you have a fixed or a drop bottom, I consider the real effective difference between a drop bottom and a fixed bottom cupola is this, and this only—that the cupola men are saved the very exhausting task, especially on a summer's afternoon, of raking out after the cast. With a drop bottom, the sand which formed the bottom has to be cleared away each day, and a new bottom has to be put in each day. I would put that against the men's time raking out after the blow when using a fixed bottom, and then we have left the saving of the hot, exhausting labour of the men, which is considerable. Some say the drop bottom is dangerous because of the liability of the metal to leak through, but as I have had charge of four different cupolas with and without drop bottom, from four to 50 tons per blow, I can safely say it gives so little trouble that one need not consider it. With a fresh man, trouble might be experienced occasionally at first, but it is not serious at any time, no matter how big the melt or the diameter of

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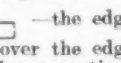
the cupola, if it is dealt with promptly. I have seen some descriptions of how to deal with this which, undoubtedly, are quite right. But I have never had any trouble in continuing the cast after a leak in the drop bottom and during eleven years have never had to pull a cupola out without finishing the cast after it has leaked. I have always thrown the wind off at once, and drained the cupola of metal and slag and then cooled the doors with water sprinkled on with a brush, and as soon as the plates have cooled down to a dark red colour, have again proceeded with the blow and have had no further trouble that day. The metal having solidified never melted out again.

Rust.—The cupola shell should be made of boiler plate; 5/16th is thick enough for a shell 7 ft. diameter by 30 ft. high to the top, and it should be painted every second year to keep it from rusting.

Height of Tuyeres and Charging Door.—The height between the top row of tuyeres and the sill of the charging door should not be less than 10 ft., but I don't think there is much value in having it any higher than 12 ft. From the charging door upwards to the top should never be contracted, as some are, to a smaller diameter; but should rather be of larger diameter inside the lining above the door, as this allows the gases a clear passage, without inconveniencing the men who are charging.

The Tuyeres.—The height from the top of the sand bed to the bottom of the bottom tuyere should not be less than 24 in., and not more than 30 in. I have great faith in two rows of tuyeres for quick and economical melting, but think the top row should only be one-half the area of the bottom row, and from the top of the bottom row to the top of the top row the distance should not be more than 12 in. The tuyeres should be spaced alternately round the circumference, a bottom and a top one following, and they should each be made of cast-iron and then bolted to the shell to prevent any leakage of air through or behind the brickwork; they should be 1½ in. or so shorter than the thickness of the lining, so that the iron trickling down does not burn them.

I have tried different-shaped tuyeres and seen other shapes tried, but I have not been able to prove the value of any one shape over another, except to point out that there is one kind which I feel a certain prejudice against—that is where they are flared round the cupola like this :—  —the edge of the top one being almost directly over the edge of the bottom one, thus forming an almost continuous tuyere or opening round the inner circumference. I consider this arrangement cools and oxidises the metal and slag which trickles down the walls; it may be suitable for blows of one hour or less, but I cannot recommend it for a blow lasting three or more hours. I prefer to allow a fair space, say 9 in. to 12 in., between a top and bottom tuyere in the circumference, to allow a passage for the slag and iron without its running across the front of a tuyere.

I consider the area of the tuyeres should be larger at the inside of the lining than next the shell, because of the hindrance to the passage of air offered by the coke in front of the tuyeres. At the shell, the area of the combined openings should be slightly greater than the area of the blast-conveying pipe or blower outlet. There should not be a bottom tuyere directly over the slag hole if it can be helped, because the wind is inclined to cool the top of the slag at this point when the slag has got low down, and the air is sometimes inclined to blow in at that tuyere and out at the slag hole. Neither should there be a bottom tuyere over the lighting door, because that leaves too short a space for brickwork, and it is difficult to keep the lining to its shape at this point.

The Slag Holes.—The slag hole should not be more than 10 in., nor less than 5 in. above the top of the sand bed; nor should it be less than 12 in. below the line of the bottom tuyere.

Blast Main and Air-belt.—The blast conveying pipe need not be made of thicker metal than 3/16th of an inch, if made of wrought iron; and it is better placed above ground than under the floor. It need not enter the air belt at more than one point, and should be of the same or slightly larger diameter than the blower outlet. I certainly advise an air-belt round the shell, and it should be of larger area than the area of the tuyere openings; this will give an opportunity for the air to enter all the tuyeres equally. I believe it advisable to have a blast pressure gauge on the air-belt, but I wish to point out that this is of no use except to tell whether the cupola is behaving the same or similarly to-day as on other days; and I don't think it correct for anyone to write or say that for a certain class of castings the air pressure should be a certain amount per square inch, as this is very misleading to the average foundryman. I have tried the blower on at its full revolutions with the cupola stopped up in the usual way—that is, the bed in, the fettling door stopped up, also the tuyeres and tap hole and slag hole, but without any material inside—and I could not get ½ oz., nor even the slightest pressure showing on the water gauge; yet that same cupola when melting usually commenced with a blast pressure of about 13 or 14 ozs., and after blowing, this had usually risen to about 18 ozs., at which it remained for the next two hours or until the stock inside the cupola got below a certain point, when, of course, the pressure decreased. I only mention this to show that the pressure when blowing the required amount of air in is wholly due to the resistance offered to its passage by the stock of material inside, due to its height, density and diameter; and that with a short cupola—that is, 7 ft. or so—one should not expect it to blow enough air in to get the same blast pressure as another gets with a higher cupola of, say, 12 ft., both measured between the top tuyeres and the sill of the charging door.

Poking the Tuyeres.—I am strongly opposed to the poking of tuyeres with a bar, because I have well proved its bad effects. I know this advice may be strongly disputed, although I have been advocating it for a number of years among foundrymen. Some of my friends have given it a fair trial, and have also proved its value; but others have always seen tuyeres poked when they are turning black, and as their cupola men have been brought up the same way, they have been content to leave them alone at it. I have found that if you are using more coke than is necessary, you can poke your tuyeres without having a particularly noticeably bad effect; but if you are working economically, that is, using very little more coke than is necessary to get the metal to the temperature it is required at, then you cannot afford to fool around the tuyeres with a bar, knocking all the black away, so that the cupola man can see the red fire and the metal running down. I have found that when working with a low amount of coke I could poke the tuyeres until the cupola almost stopped melting, because of its becoming solid across.

Let me try to explain what happens, as I have observed it. The iron and slag which trickles directly across the front of the tuyeres is blown flat against the coke, becoming oxidised and cooled by the air, and in time the whole of the front part of the opening becomes quite black; the cupola man then punches this away with a bar until he sees it all bright again, little thinking of what has become

of that which he knocked away, or of the effect on the melting going on inside. Now, let us consider what has happened. The oxidised iron and slag at the first poking usually drops straight down to the bottom of the tuyeres and remains there, starting a nose, which begins to project into the cupola thus ⌊; above the tuyere the cold air has been enabled to reach a new part directly, and it at once oxidises the iron and slag again, which begins to form a shelf or nose at that point. The next time the cupola man pokes the material in front of the tuyere it cannot drop directly down, but is pushed forward a little first, and a fresh opening is made for the cold air, a little further into the furnace; the result, I think, you can easily imagine. Now, the material is being punched forward to the centre at all tuyeres, until, in turn, it becomes so dense that the metal and slag cannot get through, and it has to run down wherever there is a space, and the cold air also has to get through these spaces, so that if the blow continues long enough there will be no spaces left; it will have become solid across, and melting will cease.

If you do not poke the tuyeres during a blow lasting, say, four hours, what happens then? The iron and slag running over the tuyeres becomes solid, as in the first instance, but only directly in front of the tuyere, and the air, being broken up and spread and not entering the cupola in such a large body, becomes warmed in its passage, and, the centre of the cupola not becoming any denser, there is always sufficient room for the molten metal to follow down as the coke is consumed and the metal and flux is fused. I do not say this is the only cause of a cupola gobbing up or arching across; all I wish to point out here is that no good purpose is served, but harm is done, by poking the tuyeres so much. A better way of clearing the tuyeres is to have a door or valve on each tuyere which can be turned over the opening to prevent air entering, when the red-hot coke will soon deoxidise and melt away the obstruction; when this is quite clear, the valve may be opened and air allowed in as before. Insufficient fluxing is a more common cause of a cupola gobbing up or arching across than all the other causes put together.

The Use of Fluxes.—I do not think I shall be anticipating or enroaching on the Paper of my friend, Mr. Swinden, if I state here the reason for fluxing. When coke is burnt to its utmost, there is a certain amount of ash left, which, of course, is more or less according to the quality of the coke; and clinging to each piece of pig-iron thrown into the cupola, there is a certain amount of sand, whilst along with the scrap, besides that which is sticking to it, there is always some local sand unintentionally thrown in. Now, it will be more familiar to us if we look upon the ash as sand, and if we say that in a 10-ton melt we have a quarter of a hundredweight on each ton of pig-iron, and at least a quarter of a hundredweight with each ton of scrap; and if our coke has about 8 per cent. of ash per ton of iron melted, we have a total of 420 lbs. or more of sand, or eleven 3-gallon bucketsful, to get rid of.

7 tons of pig = 1¾ cwt. sand.
3 „ scrap = 0¾ „
17½ cwt. coke at 8 per cent = 1⅜ cwt. sand.

It will easily be seen that if this solid material is allowed to remain in the cupola along with what is worn off the cupola lining, the blow cannot be continued over a very long period, because this solid material will fill up all the spaces between the coke and will gather about the tuyeres until there is no opening for molten iron to come through. Therefore, limestone, which has the property of uniting with sand when they are brought together at a suitable temperature, is put in, and, becoming fluid, they are drawn off as a slag. In this way, this large amount of sand and ash is got rid of, the cupola thus cleared, and melting permitted to go on hour after hour.

It may be interesting and instructive to know that for 18 months I used a coke containing about 6.0 per cent. of ash, and got very good results, with an average of 37 lbs. to 38 lbs. of limestone per ton of iron; and when I came to use another coke, containing 7.54 per cent. ash, which was done for over two years, I could not keep the cupola clear without 46 lbs. to 47 lbs. of limestone per ton of iron melted. Some men, on having had this explained to them and trying it, have been able to get better metal when using less coke than formerly, much to their surprise. But I have noticed that the cupola men are apt to reduce the limestone because it is difficult to break. When this is the case, it may be advisable to purchase the limestone broken, and this may be done for about 1s. per ton more. It is then in the most suitable size for cupola use, and the men will then use plenty.

Blowing.—With regard to the best method of blowing a cupola, I believe the positive blower—

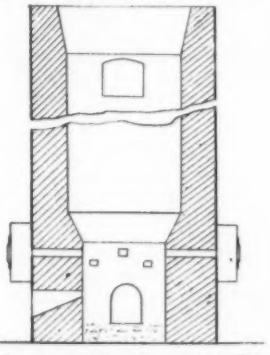


FIG. 1.—ILLUSTRATING SHAPE OF CUPOLA.

that is, a blower which will compel a certain amount of air to enter the cupola at each revolution—is the most economical machine at the present time. A fan is cheaper to instal, but is more expensive to run, and if there is above a certain resistance to the air passage, the fan will keep on running without forcing any air forward. Some fan- and blower-makers say that the amount of air required per ton of iron melted is 40,000 cubic feet. Of course, this will depend upon the amount of coke being used, for the more carbon there is to burn, the more air, of course, will be required to do it. But when using an average of 1 cwt. 3 qrs. to 1 cwt. 3 qrs. 14 lbs., of coke, including all fuel put into the cupola, per ton of iron melted, I have always found that 26,000 cubic feet has been ample. This amount has only been roughly estimated by multiplying the blower revolutions by the number of cubic feet said by the maker to be thrown forward by the blower, at each revolution, and you can depend upon it that it is rather less than this.

Shape of the Cupola.—Coming to the shape of the cupola inside the lining, I prefer to taper it (see Fig. 1), first, because less coke is required for the bed, and, secondly, because it brings the blast nearer to the centre of the charge; takes the weight of the material off the softening iron, and likewise off the bedplates and the coke; and, fourthly, it

gives a larger space for material, which, of course, is being treated as it descends, thus utilising all the heat in the best way.

In charging, I have always found it best—and have practised it for years, besides noting others who got best results in the same way—to keep the coke as much as possible in the centre of the cupola and place the iron round the walls, endeavouring to form a pillar of coke as nearly as possible up the centre of the cupola. Let me state here quite plainly, and as forcibly as I can, that this is not a fad. You who have not tried it thoroughly will be surprised to find how effective it is, and how much less coke is needed to get the same results as before in the iron. My theory of this is that the coke is not burned away so much before it gets to the point where it will do most good. Each of you, I have no doubt, have watched the flames coming up the walls, and noted how, when the stock got low down, the iron at the sides got red hot and began to melt before some of that in the centre had even got red. Now, if the iron is all placed round the walls, it must be getting hotter as it descends, and will melt much higher in the cupola than if placed in the middle. If the coke has been placed near the sides it will have partly burned at a low temperature, and the heat will have escaped up the sides without doing all the work it is capable of.

Charging.—I consider that the charges of iron should not be large. Of course, on the top of the bed a fairly big charge may be put, because the iron gets the value of the heat when the bed is lighting up, or should do so, but some furnacemen wait until the bed is burned through before commencing to charge, and they lose this heat. I admit there is an excuse where the cupola is short and the lighting door small, because they may not have sufficient draught; but, otherwise, this should not be tolerated. I have also found, as most of you have found, that the first charge of pig-iron, or the first iron melted, will be too hard to use. This, I believe, is mainly due to the amount of sulphur absorbed from the large amount of coke in the bed, and also to the slow and dull melting at first. The best coke I have used has always been by-product coke, sometimes called French coke, a name due, I suppose, to the inventor of this style of coking, and I never expect to get better. I have never seen any beehive coke to equal by-product coke. This coke comes in such large pieces that it is necessary to compel the cupola men to break it into pieces about the size of half a brick to get the best results.

It always pays for the extra labour to have all the material weighed; and it keeps men up to their best to know they are getting credit for results. Besides this, one is able to check the material bought against what is used, and of course, there is a fairly big loss in coke, because, as a rule, one only gets the net weight at the colliery, and there is a good deal of grinding down in transit and delivery and in handling at the works, besides the turn of the balance in weighing. But this should always pan out at about 3½ to 5 per cent. loss. If more loss than this is experienced, either the furnaceman is allowing himself good measure, or the proper weight is not being got; but it is usually due to the first cause, and this must be watched, or scales are of no use.

Cupola Slags.

By Thos. Swinden, B.Met., Carnegie Scholar.

Although the study of slags in general has received a very considerable amount of attention, the particular slag of interest in the foundry, viz., the cupola slag, has scarcely claimed recognition. This arises, no doubt, from the fact that the foundryman's chief aim is to get out his metal in good condition, and the slag is only there to be got rid of. He treats his charge so as to flux off the coke ash, sand, and dirt, and judges his additions of flux according to the flow and appearance of the slag; his chief object, however, is, of course, the metal. Moreover, the slag is of no great commercial value. Here is a distinction from the blast furnace, in which the characteristics of the slag are of vital importance in judging the class of iron produced. In this case, as in most metallurgical processes, the mutual reactions between slag and metal have a governing influence on the product, and an analysis of the slag gives a very good idea as to the working of the furnace. It has been deemed of interest to consider briefly the characteristics of slags, particularly the cupola slag, giving as briefly as possible, a sketch of its constitution and factors governing the fluidity and appearance.

In the first case the slag must be fluid enough to run cleanly from the slag hole. This depends on both composition and, of course, temperature. A higher temperature usually renders a slag more fluid, and also more chemically active. The fluidity of the slag is almost entirely a question of flux, although, as will be seen later, an excess of flux may mean both damage to the lining and loss of iron.

In order to consider briefly the component parts of a slag, it is first necessary to make quite clear what is meant by acid and basic material. By way of definition, it may be said that an acid is the oxide of a non-metal, and a base is the oxide of a metal. This is by no means perfect, but is a useful general rule. Acids and bases have strong chemical affinity for each other, the actual affinity depending, of course, on the particular pair of compounds. The very simple experiment—ammonia, a strong base, uniting with hydrochloric acid, a strong acid—will clearly illustrate this. The molten acids and bases met with in slags may be considered to react in much the same fashion.

It is necessary, in the first place, to note, of the compounds occurring in the slag, which are acid and which basic in character. We shall then understand better the counteracting or the co-operative action of the different compounds. The cupola slag is what is known as a silicate slag, consisting of silica combined with a series of metallic oxides. The oxides

occurring in a normal cupola slag may be classified as follows:—

Acid.		Basic.	
Silica	SiO_2	Lime	CaO
Titanic acid	TiO_2	Iron oxide	FeO
Phosphoric acid	P_2O_5	Manganous oxide	MnO
Sulphuric acid	SO_3	Alumina	Al_2O_3
		Magnesia	MgO
		Soda	Na_2O
		Potash	K_2O
		Baryta	BaO

Certain substances, neither acid or basic, *i.e.*, "neutral," may also be present, *e.g.*, calcium sulphide (CaS), calcium fluoride (CaF_2) if fluorspar has been used; and small quantities of many rarer earths may also occur. There is a point of contention in the foregoing table, viz., whether alumina shall be classed as acid or basic. Opinions are very divided, and probably there is considerable truth in the statement of Elbers,* that if the silica in the slag is low, alumina acts as an acid, and if silica is high, alumina acts as a base. Phillips,† speaking of blast-furnace slags, considers Al_2O_3 as an acid, in blast-furnace slag containing 33 to 36 per cent. of silica. It will be seen, however, that in cupola slags with higher SiO_2 values, alumina works out better as a base.

This brings us to the question of balance of acids and bases in a slag, viz., the acidity or silicate grade of the slag. It must be borne in mind that the acids and bases react and combine in perfectly definite proportions. Much work has been done in determining exactly how these acids and bases combine, the temperature of fusion of the resulting compound, and other problems of direct bearing on the practical working of fluxes and slags. The fusibility data of the different groups of acids and bases, is, however, far too large to consider in detail in such a paper as this. Moreover, notwithstanding the value of fusibility curves, say for compounds, lime-silica, magnesia-silica, lime-alumina-silica, and so forth, yet the influence of small quantities of, say, iron oxide, manganese oxide, or especially fluorspar, is so profound as to render a direct application of the data rather difficult.

First as to the classification of slags according to silicate grade. The almost universal plan has been to compare the oxygen in the acid oxides to that in the basic oxides. That is, one compares the relative *strength* of the acids and bases. The slags are named according to this ratio, and Table I. gives a classification of these names, together with a broad statement as to properties.

The last two columns are added as a rough guide in considering cupola and blast-furnace slags. The appearance depends to a great extent on the sampling, and, moreover, there are many slags which are stoney, possibly intensely basic, and are extremely difficult to melt.

TABLE I.

Nature of Slag.	Grade.	Ratio. Oxygen in Acid. : Oxygen in Base.	Proportion.	Range.	General Appearance.	Fusibility.
Basic ...	Subsilicate ...	1 : 2	½	0.5 — 0.75	Stoney	Easily fused. Limpid slag.
Neutral...	Mono-silicate ...	1 : 1	1	0.75 — 1.25	Stoney, Crystalline	Less easily fused.
,, ...	Sesqui-silicate...	3 : 2	1½	1.25 — 1.75	Crystalline ...	Still less easily fused.
,, ...	Bi-silicate ...	2 : 1	2	1.75 — 2.5	Glassy	Difficult to fuse. Forms viscous mass; draws out into threads.
Acid ...	Tri silicate ...	3 : 1	3	2.5 — 3.5	Glassy, Enamel ...	Very difficult to fuse.

TABLE II.

Silicate grade.	Silica required by one part of				Pure Calcium Carbonate required by 1 part of		
	MnO.	MgO	CaO	FeO	SiO_2	TiO_2	Al_2O_3
0.5	0.21	0.37	0.27	0.21	6.66	5.00	3.91
0.6	0.26	0.44	0.32	0.25	5.52	4.17	3.24
0.7	0.30	0.52	0.38	0.29	4.73	3.57	2.79
0.8	0.34	0.60	0.43	0.34	4.14	3.12	2.44
0.9	0.39	0.67	0.49	0.38	3.68	2.78	2.17
1.0	0.43	0.74	0.54	0.42	3.33	2.50	1.95
1.1	0.47	0.82	0.60	0.46	3.00	2.27	1.77
1.2	0.51	0.90	0.65	0.50	2.76	2.08	1.60
1.3	0.56	0.97	0.71	0.54	2.57	1.92	1.51
1.4	0.60	1.04	0.76	0.58	2.36	1.78	1.40
1.5	0.64	1.12	0.81	0.62	2.22	1.67	1.30
1.6	0.68	1.20	0.86	0.67	2.07	1.56	1.22
1.7	0.73	1.27	0.92	0.71	1.95	1.47	1.15
1.8	0.77	1.34	0.97	0.76	1.84	1.39	1.08
1.9	1.81	1.42	1.03	0.80	1.74	1.32	1.02
2.0	0.85	1.50	1.08	0.83	1.67	1.25	0.98
2.1	0.90	1.57	1.14	0.87	1.58	1.20	0.93
2.2	0.94	1.64	1.20	0.92	1.51	1.14	0.89
2.3	0.98	1.72	1.25	0.96	1.44	1.09	0.85
2.4	1.03	1.80	1.30	1.00	1.38	1.04	0.81
2.5	1.07	1.87	1.36	1 04	1.32	1.00	0.78
2.6	1.11	1.94	1.42	1.08	1.27	0.96	0.75
2.7	1.15	2.02	1.46	1.12	1.23	0.93	0.72
2.8	1.20	2.10	1 52	1.16	1.18	0.89	0.69
2.9	1.24	2.17	1.57	1.20	1.14	0.86	0.67
3.0	1.28	2.24	1.62	1 24	1.11	0.83	0 65
3.1	1 33	2.32	1.67	1.30	1.07	0.81	0.63
3.2	1.37	2.40	1.72	1.34	1.03	0.78	0.61
3.3	1.41	2.47	1.77	1.38	1.00	0.76	0.59
3.4	1.45	2.54	1 83	1.42	0.97	0.74	0.57
3.5	1.50	2.62	1.88	1.47	0.94	0.72	0.55

TABLE III.

Substance.	Factor for Oxygen Content.	1 part of Substance requires following Weight of Silica for			
		Mono Silicate.	Sesqui Silicate.	Bi Silicate.	Tri Silicate.
CaO	0.285	0.536	0.803	1.07	1.60
$CaCO_3$... ...	0.160	—	—	—	—
MgO	0.400	0.750	1.125	1.50	2.25
$MgCO_3$ ...	0.190	—	—	—	—
Al_2O_3	0.466	0.873	1.310	1.75	2.62
FeO	0.222	0.417	0.625	0.83	1.25
MnO	0.225	0.422	0.633	0.84	1.27
		Calcium Carbonate required.			
SiO_2	0.533	3.33	2.22	1.67	1.11

* "Berg. und Hüttenmannisches Zeitung," Vol. xlvii p. 253.

† "Alabama Geolog. Survey," 1898, p. 45.

To save time in calculating oxygen equivalents in considering fluxes, tables have been prepared giving equivalent weights of the more common acids and bases required to satisfy each other, and to form any grade of slag.

Table II. is such a table compiled by Wiborg,* whilst Table III. is another useful set of figures by the same authority, and Table IV. is a similar set by Professor Balling.†

Before leaving the tables it may be well to calculate out for an example the silicate grade of, say, a fairly thick cupola slag. Thus:—

Composition.	Per cent.		Oxygen Content.			
SiO_2	54.36	×	0.533	=	28.97	28.97 acid.
Al_2O_3	7.22	×	0.466	=	3.41	
CaO	23.60	×	0.285	=	6.72	
MgO	0.81	×	0.400	=	0 32	
MnO	7.20	×	0.225	=	1.62	
FeO	5.76	×	0.222	=	1.28	13.35 basic.

$$\text{Silicate Grade} = \frac{28.97}{13.35} = 2.17 \text{ or Bisilicate.}$$

The tables are, of course, of considerable value in judging fluxes, as, say, for calculating a blast-furnace charge, to give a certain grade of slag. Space will not permit of a detailed description, but the process is simply this:—

(1) Look out the silica required for each base (to form the particular grade of slag).

(2) Multiply by the percentage of the bases in the average ore charge.

(3) Sum the silica values and deduct from silica already present in the charge.

(4) From tables convert this excess silica into lime or limestone necessary for fluxing.

TABLE IV.

For ascertaining the necessary amounts of Bases to convert given amounts of Silica into Slag.		For ascertaining the necessary amounts of Silica to convert given amounts of Bases into Slag.	
One Part by Weight of Silica requires	Parts by weight of Bases.	One Part by Weight of Base requires	Parts by weight of Silica.
For Monosilicates—		For Monosilicates—	
Lime	1.86	Lime	0.535
Magnesia	1.33	Magnesia	0.750
Alumina	1.14	Alumina	0.873
Ferrous Oxide ...	2.40	Ferrous Oxide ..	0.416
Manganous Oxide	2.36	Manganous Oxide	0.422
For Bisilicates—		For Bisilicates—	
Lime	0.93	Lime	1.070
Magnesia	0.66	Magnesia	1.500
Alumina	0.57	Alumina	1.747
Ferrous Oxide ...	1.20	Ferrous Oxide ..	0.833
Manganous Oxide	1.18	Manganous Oxide	0.845
For Sesquisilicates—		For Sesquisilicates—	
Lime	1.24	Lime	0.803
Magnesia	0.88	Magnesia	1.125
Alumina	0.76	Alumina	1.310
Ferrous Oxide ...	1.60	Ferrous Oxide ...	0.625
Manganous Oxide	1.57	Manganous Oxide	0.633

Ordinary limestone is safely taken at 80 to 85 per cent. active $CaCO_3$.

The relation of acids to bases has been considered, but there still remains an all-important point from a practical point of view, viz., the most fusible proportion in each class of combination. As has been previously noted, this is a very large subject, but a brief summary may be helpful when considering slags more fully. The following notes are from Wiborg's "Metallurgy," and are the work of R. Akerman, published 1886.

SILICATES WITH ONE BASE:—

Lime-silicate.—1.5 to 3 silicates are most fusible. Below 1 very difficult to fuse.

Magnesia Silicate.—All extremely difficult to melt.

Alumino Silicate.—Practically infusible.

Iron Oxide (FeO) Silicate.—Easily fusible, particularly the more basic silicates. Mono-silicate most fusible.

Iron Oxide (Fe_2O_3) Silicate.—Much less fusible than FeO silicates, only tri-silicate anywhere near fusible.

Manganous Silicate.—Rather less fusible than corresponding FeO silicates, but easily fusible.

The difference between the two iron oxides, ferrous (FeO) and ferric (Fe_2O_3), is very interesting.

SILICATES WITH SEVERAL BASES:—

Lime Magnesia-Silicates.—

Silicate Grade:—

1.5.—Most fusible lime; magnesia = 7:3.

2.0.—Most fusible lime: magnesia = 7:3, and with this ratio is more fusible than corresponding 1.5 grade.

2.5.—Ratio 8:2 gives most fusible. This is the most fusible of all lime-magnesia-silicates.

3.0.—About 12:1 is the most fusible ratio.

Lime-Alumina-Silicates.—The tri-silicate is most fusible when $Al_2O_3 : CaO = 1:20$. For bi-silicate best ratio is 1:9, for mono-silicate 1:4, and for sub-silicate 1:2.

Lime-MnO-Silicates.—1 to 2 silicate most fusible proportion is MnO : CaO = 4:1.

2.5 grade, ratio = 3:2.

3 grade, ratio = 2:3. Whence one would expect that the more basic the silicate is the more MnO in proportion to CaO should go in to preserve fusibility.

The work of Boudouard (Journal Iron and Steel Institute I., 1905) on blast-furnace slags contains a large amount of data on fusibilities.

Leaving now the somewhat scientific aspect, and considering the practical application, it will easily be understood why in the case of an acid siliceous gangue a base must be added to form a fusible flux. Since the double silicates are more fusible we find these very frequently, as, for example, blast-furnace slag—a double silicate of lime and alumina. Cupola slags contain silicates of lime, alumina, ferrous oxide, manganous oxide, etc.

For basic gangues, an acid, silica sand, or siliceous slag may be used for fluxing.

Fluorspar thins a slag, and has claimed some attention in cupola melting, especially in America. The use of fluor in the cupola, however, has not been taken very seriously in this country. Of course, in basic Siemens practice it is almost an essential. According to Roberts Austen (*loc. cit*) the calcium fluoride is found, as such, in the slag, melting without decomposition. The action would thus appear to be purely a question of a solution of the fluoride in the silicates producing a lower fusion point.

Two main axioms to be remembered in considering slags, are:—

(1) There is always a tendency for an acid material to search out and combine with basic, and *vice versâ*.

(2) For every class of combination of a series of acid and basic oxides, there is a certain ratio of one to the other which will produce the most fusible slag.

* Wiborg—"Jarnets Metallurgi," 1904, p. 470, et. seq.

† Balling—"Compendium der Metallurgischen Chemie," 1882. See Roberts Austen "Introduction to Metallurgy," p. 261.

The concluding section consists of analyses and notes on a few cupola slags, personally sampled recently. The author would here take the opportunity of tendering his heartiest thanks to Mr. J. Davies and Mr. C. King, of the Bessemer department, and Mr. W. Walker and Mr. J. Knowles, of the Foundry of Messrs. Samuel Fox & Company, Limited, Sheffield, for their very friendly co-operation in sampling the slags. The analyses have been made in the Stockbridge Works laboratory, and the author would specially thank Mr. G. Glenn for his services in this direction.

The first series are slags from an ordinary foundry cupola melting No. 2 hematite iron, and using, say, 50 per cent. new pig. The iron would have a composition thus:—

Combined Carbon	... ...	0.50 per cent.
Graphitic Carbon	... ...	3.50 ,,
Silicon ...	... ...	2.25 ,,
Manganese	... ...	0.80 ,,
Sulphur ...	... ...	0.035 ,,
Phosphorus	... ...	0.045 ,,

Limestone was added to the extent of about 1¾ per cent. of the iron, in normal working.

Sample I. was taken when the slag was running very thick, II. was a good medium, and III. was given at the rate of 3 per cent. limestone, and ran thin. The coke used was Oswaldtwistle, and analysed:—Ash, 6.35 per cent.; sulphur, 1.11 per cent.; moisture, 1.30 per cent.; fixed carbon, 91.24 per cent. The blast pressure was about 14 in. water. Table V. gives the analyses, with notes on appearance.

TABLE V.—*Metal Slags.*

Sample No.	Melting.	Analysis.							Silicate grade.	*Appearance.	Streak (or colour of powder).
		SiO_2.	Al_2O_3.	FeO.	MnO.	CaO.	CaS.	MgO.			
I.	Thick ...	50.05	4.68	14.97	2.23	27.42	0.110	0.43	1.90	Hard crystalline stony centre. Glassy exterior. In glassy, dark greenish brown.	Dirty greenish brown
II.	Medium	44.0	5.01	15.55	3.07	31.92	0.120	0.36	1.49	Slightly spongy on top. Dense, glassy, of brownish green tint.	Light brownish green.
III.	Thin ..	44.6	5.52	21.51	2.67	24.53	0.110	0.13	1.49	Dense, glassy. Easily splintered. Dark olive green.	Brighter green.
IV.	Thick ..	54.36	7.32	5.76	7.20	23.60	0.031	0.81	2.17	In transmitted light deep brown. Interior shows bluish green.	Light greyish brown.
V.	Medium	62.50	7.02	12.97	8.37	7.98	0.033	0.89	2.81	Dark olive green in transmitted light. Direct shows mixture dark brown and dark olive green.	Light greenish brown.
VI.	Thin ...	51.40	8.36	20.84	7.56	11.18	0.030	0.44	2.14	In transmitted light greenish brown. Direct light shows interior rather dark olive green.	Dark greenish brown.

* Samples caught and cooled in iron mould giving sample 3 in. by 2 in. by 2 in.

TABLE VI.—*Spiegel Slags.*

Sample No.	Analysis.							Silicate grade.	Appearance.	Streak (or colour of powder).
	SiO_2	Al_2O_3.	FeO.	MnO.	CaO.	MgO.	CaF_2			
VII.	41.00	6.19	1.75	39.06	11.62	0.58	—	1.40	Dark brown, heavy, inclined to be stony, crystalline, of light greenish brown tint. Exterior deep chocolate brown.	Light brown.
VIII.	44.60	6.27	2.84	29.46	16.80	0.58	—	1.62	Very much lighter in colour. Very spongy.	Very pale brown.
IX.	50.05	10.80	0.62	22.86	15.10	0.414	—	1.80	Light, porous, and almost pure meerschaum colour	Pure creamy white.
X....	33.00	5.85	6.05	16.56	36.45	1.45	0.80	0.94	Heavy stony crystalline. Deep chocolate brown.	Brown.
XI.	34.00	5.68	6.23	10.70	38.59	3.2.	0 82	0.93	Denser than X. Colour more greyish tint. Surface shows "manganese brown."	Greyish brown.
XII.	47.30	10.20	2.54	20.02	9.60	1.45	—	1.66	Very similar to VIII. ...	Very pale brown.
XIII.	23.70	0.04	0.50	32.36	42.32	—	—	0.64	Brilliant green. Stony crystalline until decripitation.	Bright grass green.

It will be seen that as the slag is thinner so the iron content increases, silica tends to fall, whilst lime also is lower in the thin sample, in spite of the fact that more limestone was charged. Alumina steadily increases. The explanation would appear to be that in I. either there was insufficient limestone, or the temperature was too low for the lime to react and form together with alumina and iron oxide a very fluid slag. The thin slag is an almost black "obsidian" glass, characteristic of the slag just after a limestone addition.

Slags IV., V., and VI. form a supplementary series from a cupola melting mixed hematite irons for Bessemer blowing.

The FeO and CaO columns confirm what was said on the first three slags. The FeO steadily increases, and CaO in the thin sample is only half what it is in the thick. The CaO in the case of III. and VI. has taken FeO and formed a very fusible silicate.

The colours are interesting, and will be dealt with later.

Before leaving this section the following slags may prove an interesting innovation:—

Cupola lined with *acid* lining melting spiegeleisen, of average composition:—Carbon, 4.50 per cent.; manganese, 11.50 per cent.; silicon, 0.75 per cent. Limestone to the extent of 2 to 3 per cent. was the flux. When the flux is not working well, or if the cupola is cold, the slag is brown, heavy, and inclined to be stony. The analysis is given, No. VII. in table VI. The MnO, it will be noticed, is very high—nearly 40 per cent. Slag VIII. is from the same cupola, a few hours later, after a double dose of limestone. The MnO is down practically to 30 per cent., and the slag is becoming lighter in colour, porous, and spongy.

Slag IX. is what is considered to be an ideal slag. It is pure meerschaum tint; light, pumice-like in appearance. The MnO is only 22.86 per cent. An interesting feature is the formation of a lime-manganese-silicate, whilst FeO is very low indeed. The remelted spiegel average analysis is:—Carbon, 4.0 per cent.; manganese, 10.0 per cent.; silicon, 0.6 per cent; showing a loss of Mn of about 15 per cent.

A most interesting comparison with the above is furnished by slags X. and XI. These are from the same cupola with *basic* lining, melting similar spiegel. The two samples are from different blows. The spiegel in this case analysed:—Carbon, 4.5 per cent.; manganese, 12.0 per cent.; silicon, 0.75 per cent. The flux was limestone, with a little fluorspar. It will be noticed that the MnO figure is considerably lower than with the acid-lined cupola. Both lime and iron are higher, and silica is lower. The slag is thus more basic in character, and as a result the basic MnO is not so easily formed and fluxed off. This is an interesting example of a practical application of the study of acids and bases in slags. The actual analyses of re-melted spiegel show, in round numbers:—Carbon, 3.8 per cent.; manganese, 11.3 per cent.; silicon, 0.25 per cent.; or only about 6 per cent. loss of manganese.

Slag XII. corresponds to a silico-spiegel 20 per cent. Mn-10 per cent. Si, remelted in an acid-lined cupola. This is a similar type of slag to VIII., but CaO is lower and SiO_2 higher. A special feature in this case was the high loss of silicon. The remelted alloy contained 18 per cent. Mn, but only about 3.5 per cent. silicon.

Slag XIII. is added as a curiosity. This was a sample of slag suspended in the basic cupola after melting the cupola, and was very stiff and infusible. The slag was bright green, stony in appearance, and "fell" within a few minutes of raking out, into powder. The high lime and manganese would account for this. The silicate grades are very interesting, particularly in comparing the "acid" and "basic" cupolas.

Some notes have already been made as to the influence of certain metallic oxides on the colour of the slag. The actual colour will depend considerably upon the acidity of the slag, rate of cooling, and other factors. The difference between the green or blue glassy appearance on the outside of a CaO_1-Mgo-Al_2O_3-silicate, to the white or grey crystalline stony interior (both having identical composition), is striking in this respect. Hence the following notes are not advanced as exhaustive, but rather as an approximate guide.

Iron Oxide (*FeO*).—In the first stages grass green, changing through greyish-green to brown, and finally almost to black.

Manganous Oxide (*MnO*).—Yellow to brownish-green, changing to yellowish-brown. When very high deep brown.

Alumina (Al_2O_3).—Excess tends to produce opalescence, and to keep a slag vitreous.

Lime (*CaO*).—By virtue of its basic nature tends to give a dull stony slag when very high.

Vanadic Oxide is said to produce a bluish slag.

Titanic Oxide in stony slags gives a peculiar purplish-grey, whilst in glassy it may be brown or violet.

The sulphides have a strong influence. Manganese sulphide gives yellowish- to brownish-green; ferrous sulphide, dark brown to black. The presence of two or more together of these compounds render it difficult, except, perhaps, in any particular line, to say definitely what the colour shows. The presence of much iron and manganese together makes a very dark slag, but the difference in the greens, when apart, is quite clear. Examples will make these points clear. The "streak," or powder colour, is really the true colour of the slag.

This question of colour is a deeply interesting one, and would amply repay, even from a purely practical standpoint, a close investigation.

Appendix.

The following analysis of materials referred to in the paper may prove of use, and are included for the sake of completeness:—

Analyses of Refractory Materials, etc.

	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	MnO	TiO_2	CaF_2	Alkalis	CO_2	SO_3	P_2O_5
Limestone ...	2.5	1.0	48.5	2.0	2.0	0.3	—	—	—	41.8	—	—
Magnesite brick	3.0	1.5	3.0	90.0	1.5	—	—	—	—	—	—	—
Dolomite	3.0	1.0	30.0	20.0	1.0	—	—	—	—	44.0	—	—
Fluor Spar ...	3.5	1.0	—	0.18	1.0	0.17	—	92.80	—	—	—	—
Silica Sand ...	97.0	1.0	0.5	0.2	0.5	—	0.2	—	0.5	—	—	—
Red Sand	85.0	4.0	0.8	0.5	6.5	—	—	—	1.0	—	—	—
Firebrick, Good	75.0	19.0	0.5	1.0	3.5	—	—	—	1.0	—	—	—
,, Common	58.0	32.0	1.0	1.0	6.0	—	—	—	1.5	—	—	—
Ash from Coke*	31.94	13.96	9.03	5.80	28.52	—	—	—	—	—	10.01	0.41

* Coke made from Soft Coal. Analysis of Coke:—Carbon 89.17; Ash 9.22; Moisture 0.64; Sulphur 1.14.

Malleable Cast Iron; Some of its Features, and How it is Manufactured in Sweden.

By G. A. Blume.

In Scandinavia, *i.e.*, Sweden, Norway, Denmark, and Finland, the use of malleable cast iron was practically unknown up to about 1876 or 1880, when a small foundry was started in the neighbourhood of Stockholm. Still later, other small foundries were built in Copenhagen and Christiania as well as in a few additional places in Sweden. A couple of years ago a small foundry was started also at Jakobstad, Finland. The total annual output in Scandinavia up to 1906 may be put at about 500 tons—not a very great figure if it is borne in mind that Sweden alone, should it use malleable cast iron in the same proportion to population as is the case in the United States of America, would place on the market not less than about 70,000 tons a year.

For the sake of those who are not conversant with the making of malleable cast iron, I will briefly explain the difference between the Reaumur and the American black-heart systems, which lies in the annealing process. The former generally uses a more highly oxidising packing or annealing medium, mostly pulverised hematite ore, and anneals at a higher temperature and for longer time, the exact period depending upon the nature of the ore. The latter system uses as packing mostly hammer scale or scale which comes more or less clean from the steel rolling mills. But other packings are also used in annealing according to this system, as for instance, the slag which, during melting in air furnaces, is skimmed off the bath and afterwards pulverised. I shall later give you examples of still other packing materials with which I have experimented in my works. The black-heart process allows annealing to take place at a lower temperature than the Reaumur process, while the operations are stopped sooner, and consequently can be performed quicker.

A comparison between the results of the two systems shows in the former case a steely fracture with a homogeneous crystallisation all through, and in the latter case a black-coloured fracture with a lighter greyish rim all round the edges. In one case the annealing process is carried on until most of the carbon has gone out of the iron, bringing it nearer to wrought iron, in the other the process is stopped when only the skin of the casting is decarburised, while the carbon towards the interior of the piece is changed from its combined state in the hard casting to a new kind of amorphous carbon called by the German Professor Ledebur "temper" carbon, which analyses as graphitic carbon, but which still gives to the casting a certain degree of malleability.

Regarding the uses of the two different systems of malleable cast iron, I wish to give as my opinion that it is not right to condemn the one and praise the other, as I believe both have their applications. For castings which have not to be machined to any extent other than the drilling or tapping of a hole, and furthermore have only to be painted, galvanised or otherwise coated, or for castings for general railroad work, for agricultural machinery, for boat fittings and other hardware, and numerous other purposes where the decarbonised surface is allowed to remain intact, I believe the black-heart process to be more suitable than the Reaumur process; but, on the other hand, for castings which are to be machined or tooled to a greater extent, or for pipe fittings and similar work, I think the latter process is preferable. But the one kind of material cannot be said to be in general either better or inferior to the other.

Coming back to the main theme of this Paper, namely, the manufacture of malleable cast iron as it is carried on in Sweden, in the year 1906, we had working in Sweden three malleable iron foundries, of which two melted in crucibles and annealed in hematite ore on a small scale, while the third melted in a small open air-furnace and annealed in rolling mill scale. The capacity of the two first-named foundries was together about 150 to 200 tons a year, and of the third about the same quantity. At that time the foundry in which I am interested was built. We started casting in the beginning of 1906 and made during that year about 350 tons. Next year we made about 750 tons, in 1908 about 1,200 tons, and in 1909, the year of the big strike, about the same quantity. At present we are making castings at a rate of about 1,500 tons a year. The foundry has a floor area of 39,000 square feet, of which the moulding floor occupies 25,000 square feet, and the annealing department 5,000 square feet, the balance being allotted to cleaning, shipping, core making, engine room, pattern shop, generator house, offices, etc.

The melting equipment consists of two air furnaces, one of which is always kept in reserve for repairs, and a cupola for the making of annealing pots. The annealing department has five furnaces, of which four are built for direct coal firing and one is fitted with producer gas, which we make ourselves. In building the annealing furnaces, which to a large extent has been done in the course of the development of the business, I have employed different flue systems, in order to ascertain which would be most suitable. Thus, the first two ovens have only one flue, which goes under the oven floor forwards and backwards some six or eight times until it finally through one single opening runs out into the chimney through a damper. In building the next two furnaces, I went to the other extreme in letting each separate flue run direct from the front end of the furnace under the floor to the back and out through a damper further into the chimney flue, and finally in constructing the fifth and last oven I employed still another system. The flues in this latter case do not run lengthwise under the floor, but crossways, and each flue has but one bend, thus running in two lengths under the floor before going out through a damper into the main chimney flue. There are consequently eight rows of flues under the oven floor, but only four dampers over the four flues, which go outside of oven to the stack.

The moulding equipment is made up practically entirely of moulding machines and moulding presses, the greater part according to American methods. For the general run of jobbing work we usually use gated patterns (at least when any considerable numbers are ordered at one time), made of metal, either brass or other suitable pattern metals, or even aluminium, for heavier patterns. For standard works the patterns are generally mounted on iron plates and these fitted on machines, as for instance, patterns for pipe fittings, which are mostly mounted for moulding on a Berkshire automatic moulding machine and in moulding presses with flask-lifting devices. The gating of patterns is done in the customary way, and

of late I have introduced a gating system by which the runners are attached to light aluminium frames to which is screwed an air vibrator—this in order to avoid the often excessive rapping on the pattern by hand. On most of our moulding presses with flash-lighting device, the rapping is done through vibrators attached to the moulding machine itself. For deep patterns with straight draft we mostly use machines by which the pattern through a simple lever movement is raised from the mould. In these machines the cope and drag parts are moulded from patterns attached to the two sides of a heavy iron plate, which turns on trunnions. The patterns for these machines are frequently made in plaster of Paris. In general the matchbs for gated patterns are made in hard sand from a mixture of some old and new sand, together with linseed oil. We never use litharge in the mixture as we have found this superfluous.

The equipment for cleaning castings comprises tumblers, large and small, with air suction, fans and sand-blasting apparatus. Throughout the whole plant are laid pipe lines for compressed air, which is used for the rapping of the patterns while moulding, for cleaning patterns and plates, and for sand-sifting. The power is all electric, and furnished to individual motors in all the different departments all through the plant.

The melting, which is usually done twice a day, takes four hours for a heat of about six tons, including the time required for tapping, and the coal consumed is generally about 1 lb. of coal to 2 lbs. of iron, although we have at times attained figures as good as 1 to 3. Our coal is best South Yorkshire, and costs, at present, delivered at the works, about £1 a ton.

The annealing is performed with the black-heart castings at about 740 degrees C., and this temperature is kept up for about 72 hours. The coal consumption for this annealing is generally in the older furnaces ½ lb. of coal per 1 lb. of iron annealed. In the gas-fired furnace and in the furnace No. 5 previously referred to, the coal consumption is about ¼ lb. to 1 lb. of iron annealed. For the Reaumur iron, principally pipe fittings, we keep the annealing temperature at about 810 to 830 degrees C. for a period of about 120 hours at full heat. As packing material for these castings we use Belgian hematite ore.

The iron mixture which we generally use for malleable casting purposes is made up mostly of about 14 per cent. West Cumberland hematite iron, 40 per cent. Swedish charcoal iron, and 46 per cent. white scrap. The figures naturally vary according to the class of castings to be made. It is to be noted that we never use white pig-iron in the mixture, only grey pig-iron, together with our own white scrap, made up of gates, sprues and discarded castings. As to the analyses of our mixtures, they are about as follows:—For heavy work (about ⅜ in. or more), Si, 0.60 per cent. to 0.70 per cent.; P, 0.05 per cent.; M, 0.14 per cent.; S, 0.03 per cent.; and total carbon about 2.85 to 3.10 per cent. For lighter sections the Si is often run up to 1 per cent. or 1.10 per cent.

The iron is poured very hot, usually, at a temperature of about 1,470 degrees C., and is carried by the moulders themselves to their moulding floors in small hand ladles holding from 40 to 60 lbs. each.

Although the general complaint among the Swedish manufacturers is that the Swedish labourer does not give the average daily output of a good labourer, at our works we have succeeded quite well in this respect, at least in our malleable iron foundry department. One hundred moulds a day 14 in. by 16 in., in addition to the laying of some cores, are common on regular squeezer work, and on special machines the performance is frequently a great deal more. Everything is paid on the piecework system, both moulders, floor hands, cleaners, core-makers, annealers and others. The melters and firing men are paid by the week or month.

I might say, furthermore, that we, after a recent strike in our core-making department, started to employ girls as core-makers, and now we have principally girls, and only a smaller number of boys for heavier cores. The class of goods that we make is principally for agricultural machinery for railroad cars, pipe fittings, boot-hardware, together with hardware of all kinds and machinery parts in general—as will be noted quite a variety of work, necessitated by the limited market in our small country for these specialities.

Now as regards cost, I take it that it will interest the English makers of malleable castings to learn what results others in that respect are getting. Putting our coinage and weights into English equivalents, I may mention that in our town we pay for common labour in general 3s. 4d. a day for ten hours' work, and to skilled moulders from 4s. 5d. to 5s. a day. The machine moulders we cannot put in the same category as the moulders, but to start with they get the wages of common labourers. With iron at £4 14s. 5d. a ton and coal at £1 a ton, our average cost per lb. of finished goods is 2d., including general expenses and depreciation on buildings and machinery. How these figures compare with English conditions I do not know, although I should be very interested to learn. That they compare very favourably with the other makers of malleable castings in Sweden and the other Scandinavian countries is, on the other hand, certain, although I am very well aware that as yet we have not by far reached the figures which we are aiming at. Especially will this be noted when we compare the figures mentioned with those of the large American foundries. At least, one Chicago foundry is making malleable-iron castings for agricultural machinery at a shop cost of 2¼ cents per lb., or about 1⅛d., or not much more than one-half of the foundry cost which I must figure with in my works.

I shall later revert to the matter of the manufacturing costs of my castings and the consequences which my efforts towards the reduction of these costs have had. Before turning to this, however, a brief account of the system of control of the quality of castings which we are employing at our works will be given.

All irons are bought according to analysis, and all carloads received are analysed by the laboratory to learn how closely the specified analysis is followed. The mixtures are made up according to analysis, and the iron of every melt is analysed daily. In every melt we take samples, partly in heavy blocks about 3½ in. square, partly in round test plugs about 1¼ in. diameter, and finally in wedge-shaped test bars 6 in. long, 1 in. wide and with the thickness tapering from ⅝ in. to 1/16 in. All test pieces are marked with the date and number of heat and can thus easily be identified. The square and round bars are kept unannealed as a record on the fracture of iron in the hard state, and the wedge bars are packed together with castings from the same heat of which the bars are samples. After annealing, these test bars are hammered and made to curve up from the thin end; the distance from the base at which fracture takes place determines the quality of the iron. From a certain number of heats tests are also made to determine the tensile strength. To control and record the firing of and temperature in the annealing ovens we use recording pyrometers. By comparing after each

anneal the analyses of iron in the charge and of the iron melted with the fractures of the hard test pieces, and the testing of the wedge bars with reference to the length and height of the heating in the annealing ovens, we have a pretty good record of the material from its origin to the final result, with all the important phases of the manufacturing process noted.

It has always seemed wrong to me that so much fuel and heat should be wasted in the melting of iron, as is the case in air furnaces, and I have studied the construction of these furnaces very carefully. We had frequently changed our furnaces in form and general design, we had tried to preheat the blast, we had melted with a high blast pressure and with low pressure, we had carefully gone into the question of taking care of at least some part of the waste stack heat, either for heating or for power, and still, although something had been gained, the cost of melting was far too excessive. I therefore turned my mind to open-hearth furnaces, which I knew were being used in a few foundries in America. The reports I was able to get from the States were, however, not altogether satisfactory, as it seemed necessary to have the ovens very large and to run continually day and night in order to get economical results. But I did not feel satisfied in letting this matter drop, as I did not quite see why the open-hearth furnace, or some modification thereof, could not be used to advantage in obtaining quicker melting with less oxidation, cheaper melting by saving in fuel and labour, the overheating of the iron so that it could be taken in larger ladles to the different moulding floors, and, finally, much reduced repairs of the furnaces, an item which is comparatively very large with air furnaces.

However, it seemed evident that a conclusive answer to these questions could not be obtained without trial. I therefore made arrangements with a friend who was running a steel mill and who had on open-hearth furnace of the very latest design, whereby I obtained the right to use the furnace for a time during which I was to make all the experiments necessary to determine a future course. The results of these trial meltings were in every respect a splendid proof of the suitability of the open-hearth furnace for malleable casting purposes. I found as the mean result that a 3-ton charge could be charged, melted and tapped in less than two hours—in fact, at one time these operations only required 1½ hours. The saving in fuel was very great, in that on an average 18 per cent. of coal compared to the weight of the iron was consumed. At one time a melt of 3 tons was made with a coal consumption of less than 350 lbs.* of coal. Instead of, as in melting in air furnaces, requiring one melter and at least one man to handle the slag, the melting in the open-hearth required but one man, the melter; no skimming of the bath was needed, and the firing of the gas generators was combined with other labour. The iron could very quickly be overheated so that the whole charge of 3 tons could be tapped in one ladle, and from this to smaller hand-ladles in different parts of the foundry, where it could be cast without short pouring, even the very last drops being used.

Finally, as regards furnace repairs, I may say that the open-hearth furnace which I used went more than ten months steadily without repairs, and I am confident that repairing once a year is all that would be necessary with an open-hearth furnace run for iron melting. Besides the result obtained regarding the melting and its cost, together with other different phases mentioned in connection therewith, I made extensive experiments to learn whether that type of furnace could be used even if the melting were not continuous day and night. I found that the furnace could very well be closed and the dampers shut without firing and without the furnace losing too much of its heat during the whole night; and on Sundays it could be kept warm by using a very small quantity of gas and blast.

The iron used during the experimental meltings above-mentioned was all Swedish charcoal iron with a composition generally of: Si, 0.70 per cent.; P, 0.09 per cent.; Mn, 0.04 per cent.; and S, 0.015 per cent. But poorer irons were also used which, although they required some refining, and consequently a longer time in melting, still gave equally good results as regards strength. The loss of silicon through oxidation during melting was practically none, and the control of the flame was perfect during the whole of the melting operation. A lot of the castings from the open hearth heats were later annealed, both in ore and in shale, with equally good results.

As the result of a thorough calculation based on the experience from the present plant, together with the use of producer gas for annealing, and also on the experimental meltings in the open-hearth furnace, I am perfectly satisfied that malleable cast iron of the variety which is being made at our works can be made in Sweden at a cost figure very much lower than at present, or about 1½d. a lb. when general expenses as well as plant depreciation are figured in, the cost of iron and coal being as above-named. As, however, an alteration of our present plant to such an extent as to instal all the desired improvements would involve such a radical change that practically the whole plant would have to be torn down, we have decided to build an entirely new foundry plant embodying all such improvements as deemed practical.

The Hardness Testing of Cast Iron.

By Richard Mather.

The testing of hardness is still perhaps in a more unsatisfactory state than that of any other of the important properties of metals. This is due largely to the facts that there are several forms in which hardness manifests itself, and that there is no method by which all these forms can be measured in one test. Moreover, the property most often in question in actual practice in connection with hardness is what Keep calls "workability," *e.g.*, ease of machining in a casting, or durability in a tool; and this is a function of the tenacity as well as of the true or "mineral" hardness.

The usual definition of the hardness of a body as the resistance it offers to penetration does not at once suggest an obvious and direct unit such as, for example, the number of tons per square inch by which tensile strength is expressed. As a consequence of this, there is some diversity of opinion and practice among those who have put forward methods and instruments for measuring hardness.

Of late years there has been a steadily growing activity in this department of mechanical testing, as is shown by the report of P. Ludwik to the International Association for Testing Materials in 1909; and it is to be hoped that as a result there

* Probably should read 350 lbs. per ton. [Editor F.T.J.]

will gradually come about a clearer understanding of the principles on which hardness determinations should be based. Once there is a general agreement on this point, the advent of a satisfactory method and instrument will not be far off.

In the iron foundry hardness is not often deliberately sought; in most cases the necessities of machining, etc., require that it shall be avoided, and even where this is not of importance the properties desired in the casting are often inconsistent with great hardness. So that the number of cases in which hardness is aimed at for its own sake in the foundry is comparatively small; and in these it is almost always abrasion hardness, resistance to wear, that is required. This somewhat simplifies the hardness-testing of cast-iron as contrasted with, say, steel, where in one case cutting hardness, in another elastic hardness, in a third abrasion hardness, and so on, may be demanded. But cast iron has the complication that the hardness varies considerably from the surface of the casting inwards. It is the chief advantage of the Keep test that it does not ignore this variation.

It is a commonplace in the foundry that the hardness of cast iron varies with the openness of the fracture, with the shrinkage and contraction, and in a general way with the tensile or transverse strength. So much so that where the hardness or softness in itself is immaterial, but where it is important that there shall be, for instance, little shrinkage, the foundryman will usually say, not that he wants a low-shrinkage or high silicon or low sulphur iron, but that he wants a soft iron. I think that this tendency points the chief direction in which we in the foundry may find hardness tests useful. We shall probably find, each in his own particular circumstances that the hardness bears a close relation to some property or other which is important in each different class of work.

The hardness of cast iron depends chiefly upon its content of combined carbon, and also on the silicon (regarded independently of its influence on the state of the carbon). The hardness rises or falls as each of these elements rises or falls. The relations of the carbon and silicon contents of cast iron to its other properties have been so often dealt with that there is no need here to trace in detail the relations between the hardness and these other properties. The conditions of cooling affect the hardness chiefly through the carbon.

When one turns from the general desirability of testing hardness to the actual carrying-out of the tests, several difficulties occur. An ideal test should express the results in terms of the ordinary units of length, mass, and if necessary, time, so that the figures should be comparable with those obtained elsewhere under different conditions and with a different instrument. The test should be accurate, quick, sensitive to small variations, and easily applied; and the instrument should be portable so that it could be used on a large casting, which should not be damaged or defaced in the operation. But present methods fall a long way short of this perfection.

The oldest test, and by far the commonest, the file-test, does not need any explanation. Its possibilities and advantages and limitations are well enough known. Like most other tests which depend so largely on the personal factor, it is gradually being superseded where accurate knowledge is desired.

Of the more exact methods introduced in the last 25 years, Professor Turner, in his useful summary* of the present position of hardness testing selects for comparison four which are typical of nearly all that are in general use. To three of them I shall refer only very briefly.

(1) *Turner's Sclerometer.*—Professor Turner's own method consists in noting the weight with which a diamond point must be loaded to produce a standard scratch on a polished surface of the metal. This test corresponds with that of the ordinary mineral scale more nearly than any of the others. It is easily applied by the instrument called the sclerometer, which has been devised by Professor Turner; but as he notes* "some special skill is required in determining the standard scratch."

(2) *Keep's Test.*†—This is carried out in a way which makes it an excellent measure of the machining properties of the metal. The sample is drilled by a standard drill loaded with a constant weight and performing a constant number of revolutions per minute. An automatic attachment plots on a piece of paper the number of revolutions against the amount of penetration, and thus gives a line or curve inclined to the horizontal and at an angle which varies with the hardness. For the purposes of this test, Keep has designed a specially adapted drilling-machine.

(3) *Brinell's Test.*‡—The ball-pressure test has during the last 10 years received much attention. In its original form a hardened steel ball of known diameter was pressed into the sample by a known force. The pressure applied, divided by the spherical area of the indentation produced, *i.e.*, the force required per unit area of indentation, gives a number which is a measure of the hardness, since the greater the hardness the greater the force required to produce a given penetration. Small machines for the ready application of this test have been introduced, and are in use in several steel works. Professor Martens considers that better results are obtained by using a cone instead of a ball and applying the force until a fixed depth of penetration has been reached, and by his machine the depth is measured simultaneously with the application of the load. A considerable drawback to this form of test is its inapplicability to finished castings. The following results§ obtained by J. E. Stead and T. Greville Jones on Clarence pig-iron will illustrate the hardness numbers given by the Brinell machine:—

Pressure, 3,000 *Kilos. Diameter of Ball*, 10 *mm.*	Average Hardness Number.
Glazed Iron	113
No 1	104
No. 3	112
No. 4 Foundry	156
No. 4 Forge	160
Hard Forge	197
White Iron	418
Pure Swedish Wrought Iron	87
Chilled Castings gave:	
Hard Face	415
Middle Mottled	350
Grey Back	207

(4). *The Shore Scleroscope.*—This instrument was brought out a few years ago and seems already to have come into fairly wide use. A small hammer having a diamond point is made to drop freely from a given height on to the surface of the material, and the height to which it rebounds is taken as the hardness number. The principle on which this is based is not clear; the hand-book sent out with the instrument does not discuss the point. It seems that

* "Journal of the Iron and Steel Institute," 1909, vol. i.

* "Lectures on Iron-Founding," p. 114.
† "Cast Iron," by W. J. Keep, pp. 161 and 156.
‡ For full description, see "Journal of the Iron and Steel Institute," 1901, I. p. 243.
§ Proceedings of the Cleveland Institution of Engineers, 1906-7, p. 69.

in a case of impact like this, the striking energy of the hammer (which produces a permanent indentation in the material tested) is used in three ways; (1) by the elasticity of the test-piece and hammer; and (2) in producing the indentation; while what is left (3) produces the rebound. It is only the second portion which is truly proportional to the hardness, although Shore takes (3) for his hardness number. If the elasticity did not come into play, this latter would be a measure of the hardness, although the numbers would not be strictly proportional to the true hardness. But the elasticity cannot be ignored, particularly when widely different materials are being tested. This is very evident in the fact that a piece of ordinary rubber gives a rebound of about 50, ivory 45-50, and grey cast-iron, which will easily scratch the ivory, a rebound of only 36. Shore's figures appear to give an approximate measure of the hardness *plus the elasticity*, so that a material of high elasticity and low hardness can give a higher result than one of low elasticity and medium hardness. Of course, where one keeps to the same material, such as cast iron of fairly constant constitution, this discrepancy is not markedly shown, since the elasticity will vary but little, and that probably in proportion to the hardness. Even so, the results would be more nearly proportional to the actual hardness if $H \div (H-h)$ (where H = height of fall and h = height of rebound) were taken as the figure instead of h. This rather serious defect in the scleroscope does not prevent it having considerable utility for those tests for which it is suitable, and where its limitations are fully realised, particularly since its handy form renders its use quite simple anywhere where it can be got into a vertical position at right angles to the surface to be tested.

As is mentioned above, the impact must be sufficient to overcome the elastic limit of the material under test, so that a permanent indentation may be made. The hammer and drop are arranged to suit this; the former has a convex point of $\frac{1}{16}$ square inch area and weighs just over 2 grams, while the total fall is about 10½ in. This results in the formation of a just perceptible mark in hardened tool-steel, and a larger mark on soft materials.

The instrument seems somewhat to lack sensitiveness in dealing with grey irons. Castings very soft to machine have a hardness-number 30, while those which the machinists find quite hard give only 36 or 37. I have only once had a casting give more than 38; it was mottled and had a hardness 48-54. A bigger range would be much more useful.

The following table of typical results shows the hardness of several cast irons in relation to the composition and mechanical strength; after the test bar (2 in. by 1 in. by 3 ft. centres) had been broken in the transverse machine, a portion was ground on the side and tested in the scleroscope.

Sample No.	Hardness No.	Deflection.	Breaking Load.	Graphite.	Combined Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
		Ins.	Cwts.						
963	38	0.36	31	2.88	0.49	1.77	0.37	0.083	1.26
920	37	0.35	29½	2.80	0.52	1.82	0.56	0.083	1.16
943	36	0.35	29¼	2.65	0.53	1.96	0.54	0.090	1.25
1,114*	36	—	—	2.99	trace	2.70	0.35	0.060	1.6
956	35	0.35	28½	2.89	0.24	2.64	0.32	0.112	1.6
955	33	0.35	27½	2.91	0.21	2.55	0.29	0.114	1.6
915	31	0.34	29	3.01	0.15	1.99	0.54	0.075	1.6
897	30	0.37	28½	2.92	0.34	2.15	0.35	0.071	1.6

* This sample was a portion of a casting and not from a test bar.

Comparisons between the various methods show a fairly general agreement if certain limitations are recognised and observed. But there are still too much uncertainty of principle and method in hardness testing considered as a whole, and too many discrepancies in the results to be really satisfactory; although if one keeps to a single material such as cast-iron. the results obtained by any one method appear to have some real value for comparison among themselves. But as is usual in a new field of investigation, there are so far few figures available for cast iron, which appears to be having to wait while steel receives the lion's share of attention.

Coke and its Properties.

By F. K. Knowles.*

Coke may be described as the carbonaceous residue left, or the solid product obtained when coal is subjected to dry distillation. Coal, the source from which coke is obtained, is a very complex organic body, and it is found in an almost infinite variety of forms, from the wood-like brown lignite to the massive structureless ultimate product known as anthracite. Every variety, however, yields on dry distillation the solid carbonaceous residue, and although some eighty to a hundred different substances have been isolated from the volatile products, the elementary composition of this solid residue is the same in every case, but its physical properties vary almost as much as do the numerous classes of coal. It may be stated that the elementary composition of coal is no reliable guide as to the physical properties of the coke it yields, if those varieties rich in oxygen and rich in carbon are excluded. It is because of these facts, and the limited present-day knowledge of the constituents of coal which are the controlling factors in the production of the various forms of coke, that the experienced practical coke user is more to be relied upon than the chemist in the selection of coke for a specific purpose, but each in his own sphere renders useful service, and a combination of the work of both is now almost indispensible. It is when the laboratory dictates to the works, or the practical man ignores the laboratory, that trouble comes along, from an economic point of view, at least.

The class of coal from which most coke is produced is that known as the "bituminous," and for convenience this class may be sub-divided into "caking" and "non-caking" or "free-burning" coals.

A caking coal may be defined as one which under the influence of heat swells up, becomes pasty, and if the heat be continued without undue access of air, is converted into a hard coherent mass. The result is the same whether the coal so treated is in lumps or in the form of slack, but a superior coke results from treating coal in a small state of division, so much so that caking coals are usually crushed before charging into the ovens.

Non-caking or free-burning coals, if similarly treated, split up or retain their original form, the

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resultant coke being often but feebly coherent, and particularly so if slack is used. It must not be assumed that only those coals which act according to the definition of a caking coal produce a marketable coke, for one of the best Sheffield foundry cokes is produced by coking lumps of free-burning coal; in fact, apart perhaps from its black appearance, it is an ideal fuel for the cupola.

Coke and the Laboratory Report.

The points upon which the chemist can give information are quite numerous, also they are of variable importance from the practical man's point of view. The following may be required from time to time:—

(1) *The caking property of coal or*, what is of greater importance, *the character of the coke formed.*—In making any such experiments the coal is placed in a covered crucible, and may be heated in a muffle or in a wind furnace, where a temperature of about 1,000 C. can be maintained. The coal should be subjected to the test in quantities of not less than 25 grammes, and should be used in the form of small pieces, two or three in number, wedged in the crucible, and also in a small state of division, say, sieved through a 10- to the linear-inch mesh. The resultant coke will be very unlike that produced in the oven, and for purposes of comparison a coal of known coking properties should be treated similarly and at the same time. No report on the caking property of a coal should be accepted unless the percentages of moisture, sulphur, and ash are also given, for the density and strength may be due to presence of the last two constituents; also when the amounts of ash and moisture are known the percentages of fixed carbon and of volatile matter can readily be calculated and reported along with the yield of coke.

(2) *The Moisture Present in Coke.*—This should not exceed 2 per cent., although in some cases it may amount to as much as 6 per cent. The evidence of two students on this point is of practical value. The first stated that if his coke contained 2 per cent. of moisture complaints soon came to hand, but he was responsible for coke which had to be sold in the market; the other gentleman had to report on coke used in the works in which it was produced, and he stated that 6 per cent. was quite a usual amount, while more was sometimes present. Dry charcoal will absorb from the atmosphere 10 to 12 per cent. of moisture, but dry coke only about 1½ per cent., so that any surplus is due either to rain or excessive quenching, and more probably to the latter cause.

(3) *Sulphur.*—This element has a great affection for iron, or *vice versâ*, and if present in the coke it will eventually be found in combination with the iron, even when the melting is conducted under crucible conditions. Some years ago Dr. J. O. Arnold and the author proved that sulphur present in the form of pyrites (sulphide of iron) passed through the walls of the crucible and was taken up by the charge, but that sulphur when in the form of sulphur dioxide was not harmful. The sulphur present in coke is found to be the same percentage as that in the coal from which it was produced, so that about one-third of the sulphur contents of coal are driven off during coking and subsequent quenching.

(4) *Volatile Matter.*—Most cokes, if not all, retain small percentages (2 to 3 per cent.) of hydrogen, oxygen, and probably hydro-carbons, but unless the coke is soft or spongy in consequence, the effect of a slight excess is not very serious in the blast furnace or the cupola, but is a disadvantage in the crucible hole because the intense local heat is confined to a comparatively small area. This applies to a much greater degree when the amount of moisture is in question, for in the blast furnace and cupola its removal tends to keep cool the upper portions, which is rather an advantage; only it is not good business to pay coke price for water.

(5) *The specific gravity and porosity of coke.*—These taken together are important factors, but should be regarded in conjunction with the hardness and strength, for some cokes. such as may be obtained from, say, a cannel coal, are not very porous, but very friable; moreover, for cupola and crucible work, the size of the pores is the important feature, because the larger these spaces the greater the liability to form carbon monoxide during combustion, with the consequent loss of heat.

(6) *The "calorific value."*—This term is often used rather loosely and in such a way that it is difficult to understand whether the calorific *intensity* (the temperature attainable) or the calorific *power* (the amount of heat available) is referred to. For simplicity calorific power may be regarded as capital, and calorific intensity as the rate of expenditure.

The calorific power of a coke can only be determined with absolute accuracy in some of the many modifications of Berthelot's bomb calorimeter, although with care good results may be obtained with the comparatively easy calorimeter devised by Darling. There is, however, little advantage gained, although there may be some satisfaction, by the determination of the calorific power of coke, as it can easily be calculated well within the limits of experimental error by deducting the percentages of moisture and ash, and regarding the remainder as carbon with a calorific power of 8,080 heat units.

(7) *The amount of ash present in coke* should always be estimated, and in this country will usually be found to be between 3 and 6 per cent., as against 6 to 12 per cent. in other countries. In the blast furnace and the cupola the character of the ash is of secondary importance, as it may be readily fluxed away, but for crucible melting purposes the fusibility or tendency to clinker is of more importance than the percentage, and for this reason cokes with ashes containing appreciable quantities of ferric oxide or lime should be avoided.

(8) *The strength or resistance of coke to the crushing effect of the burden.*—This is an important point, but the determination of actual stresses is a difficult matter, because the shaping of pieces of coke to some standard size is anything but easy; and moreover several samples from any one consignment would be necessary on account of the variations in the coke itself. The stress for blast-furnace coke should be about 0.5 tons per square inch, that for cupola coke will not be less, whilst for crucible purposes the coke is not called upon to carry burden.

Coke in the Works.

Already it has been stated that the practical coke user must be regarded as an authority in the selection of coke for his specific purposes, and remembering that he has qualified under the greatest and also the most expensive master, experience, it may appear presumptuous to trespass on his preserves. It is, however, more than passing strange that such wide differences of opinion exist among experts, especially in the foundry. A careful investigation of the exact working conditions in a series of cases offers a promising field of research, and the probability is that the practical man is correct in his judgment within his own conditions.

The three most important metallurgical operations depending upon coke as the fuel are, the reduction of ore in the blast furnace, the melting of iron in the cupola, and the crucible process for the production of high-class steel.

In the blast furnace, coke has four important functions to fulfil. It must supply the necessary heat and also the reducing agent, which is carbon monoxide (CO); it must bear the heavy burden and remain almost intact until it reaches the tuyeres, where the real combustion takes place. The formation of carbon monoxide can be promoted by using a porous coke, as distinct from a dense one, and by having the coke in a comparatively small state of division. A soft spongy coke which is, of course, out of the question for any of the three processes under discussion, most readily yields the gas, and at a lower temperature.

For cupola purposes coke must supply the heat and carry the burden, and should be selected with a view to the prevention of the formation of carbon monoxide; that is to say, a dense non-porous coke should be employed in pieces to suit the varying diameters of cupolas. In fact, the nearer it forms a close chequer-work structure the better. The reason for this is that when carbon burns to carbon dioxide, the maximum temperature is attained; in cupola practice a plentiful supply of oxygen is admitted, and if the combustion of the coke takes place on the surface the tendency to form the lower oxide of carbon is at a minimum, but when the carbon dioxide is forced through the coke itself by reason of its porosity, the tendency to form carbon monoxide is very great. The result of this reaction is to lower the temperature seriously as two-thirds of the heat that the coke is capable of yielding is lost, at any rate, so far as the hot zone of the cupola is concerned, when carbon monoxide in formed.

The calorific intensity of coke under ordinary cupola conditions, even allowing one and a-half times the theoretical amount of air, is about 1,700 degrees C.; in practice 1,500 degrees C. may be attained. It will readily be seen that if two-thirds of the heat units a portion of the carbon of the coke is capable of generating are taken away, the temperature must fall considerably. This phenomenon is best observed under crucible melting conditions, and recently the opportunity of watching three varieties of coke in use presented itself. In the first case a new coke, somewhat resembling a gas coke in appearance, but of much greater purity, was tried. It was found impossible to maintain a temperature sufficiently high to melt the charge with this coke. The other two were tried in adjacent holes, and one of them which, when fractured, was decidedly dark coloured, but less porous than the other, showed decided superiority in maintaining the necessary temperature. The best of these cokes showed in the furnace an even intense temperature, the worst an even temperature but too low, the third intense heat equal to the first all round the separate pieces, but dull by comparison in the lumps themselves, and on poking down the coke had become decidedly soft, or in the melter's parlance, "went all in a mush." There is little doubt that in these cases the amount of carbon monoxide formed was the factor which caused the variations in temperature, yet it should be remembered that each of these cokes has about the same calorific power.

The cokes which find most favour are those which present the beautiful white, silvery, metallic appearance, and the superiority of beehive coke in this particular is as yet unrivalled, but that this appearance is an infallible guide cannot be admitted, for cokes which present it may not be thoroughly burned, and many which are inferior in appearance may possess ideal qualities. It is difficult to state exactly the cause of this difference in appearance between beehive and retort coke, and neither of the reasons usually given is perfectly satisfactory. The one generally stated is that by coking a large mass from the surface to the interior, the heavy hydro-carbons which come away from the last portion of the charge to be distilled are themselves coked on passing through the intensely hot outer layers. Against this view it may be urged that cokes which are black on fracture may be quite silvery on the outside. Another suggestion is that carbonaceous matter is deposited on the surface (just as carbon is thrown down when olefiant gas is heated), but that the air admitted before drawing the beehive coke destroys this and leaves the clean silvery surface; but the retort coke is pushed out into the atmosphere at a sufficiently high temperature to produce the same effect.

The suggested explanation that this appearance is due to a deposit formed in either of the two methods just mentioned being rendered permanent by keeping the coke in the luted up oven for about twelve hours (in an atmosphere which must be charged with hydrocarbons) after the coking is completed, appears to be reasonable. However this may be, it is difficult to maintain the claim for a decided superiority of a coke possessing this appearance, over one with equal qualities in other respects, for if a coke is to be judged by its physical properties only there are other tests, such as the "rattle" as the coke falls into a crucible hole, on which more reliance may be placed.

The Constitution of the Brass Alloys.

By O. F. Hudson, A.R.C.S., M.Sc.

The alloys which are grouped under the general title of brass are composed of copper and zinc, together with, as a rule, small quantities of other metals, and they constitute the most important series of non-ferrous alloys. Varying widely in composition and properties, the brasses include a large number of more or less well recognised alloys suitable for particular purposes, to which special names are given, such as common brass, yellow metal, Delta metal, etc.; but until recently very little was known of their constitution or the relations which exist between the component metals in them.

The metals or other elements present in any alloy may exist in three conditions, namely:—

(1) In a pure, or practically pure, state.

(2) In the form of a solid solution.

(3) As a chemical compound, which also may be dissolved in a solid solution.

In the alloys dealt with here the only element that is found in a state of comparative purity is lead, and no part of any brass or bronze can be separated or distinguished as copper or zinc or tin, etc. By far the most usual condition in which the metals exist in the useful copper alloys, or in any alloy, is as a solid solution. A solid solution resembles a liquid solution in that the solvent and dissolved substances are capable of forming perfectly uniform mixtures in more or less widely varying proportions from which the component substances cannot be separated by mechanical means. The metals entering into a solid solution cannot be recognised as such, each of the metals losing its distinguishing characteristics, which

are merged in those of the solution. Unlike liquid solutions, solid solutions are usually, and in the case of metallic solid solutions always, crystalline.* Again, in a liquid solution diffusion is rapid, and whatever the concentration, the solution is readily obtained uniform throughout. On the other hand, diffusion takes place comparatively slowly in solids, and it is for this reason that metallic solid solutions, when in the cast condition, frequently show, when examined under the microscope after polishing and etching, a core or skeleton of a dark etching material in each crystal. When a solid solution is produced by solidification from a molten alloy the solid that separates first has neither the same composition as the liquid from which it solidifies nor of the solid that is deposited after; and, as diffusion is slow in a solid and between the solid and any remaining liquid, it often happens that each crystal of the solid solution is not quite uniform in composition when the alloy is cold. Annealing, especially after rolling or otherwise working the alloy, gives crystals that are perfectly uniform in composition.

Many metals are capable of combining with each other, as well as with non-metals, to form true chemical compounds, but these compounds are generally hard and brittle, and except in special cases, *e.g.*, bearing metals, their presence in an alloy is not usually desirable. It is difficult in many cases to obtain inter-metallic compounds in a state of purity, and they are commonly more or less soluble in one or both of their components. If an inter-metallic compound is capable of being heated to its melting point without decomposition, it has, like a pure metal, a definite melting and freezing point, which is usually higher than either of its component metals.†

All alloys thus consist of either a solid solution, a compound, or mixtures of solid solutions and compounds, and rarely contain a pure metal. In any series of alloys of only two metals there can never exist together under normal conditions, *i.e.*, in a state of equilibrium, more than three separate and distinct substances, and then only at a definite temperature in an alloy of definite composition, as in the case of the freezing or melting of a eutectic. Except in such or similar cases a binary alloy never contains more than two definite and distinct substances. A eutectic is an intimate mixture of two solid substances which constitutes the most fusible alloy of the series, and at its freezing point the molten alloy (a liquid solution) co-exists with the two solid substances which form the eutectic. Thus a eutectic has a fixed and definite melting point, and is always regarded as a separate constituent of an alloy. It must be remembered, however, that it is not a single substance, but a mixture of two. Partly owing to the fact that it has a lower melting point than the rest of the alloy, a eutectic is often a source of weakness and brittleness, and is not a common constituent of the mechanically useful alloys. When an alloy contains more than two metals the number of different substances which can co-exist in it in a state of equilibrium becomes larger, the maximum being one more than the number of the component metals. The constitution of series of alloys of three or more metals is thus usually very complex, and it has been studied as yet in only a few cases.

In addition to the changes that occur during solidification, other and important changes frequently occur in alloys after they are completely solid, leading to the formation of entirely new substances, and as will be seen later, such changes occur in many of the useful brass alloys. Previous reference has been made to the slowness of diffusion in solid alloys, and other changes in the solid are often equally sluggish. In deciding, therefore, on what is the normal constitution of any alloy at any temperature, it is necessary to make sure that all changes that may occur in the alloy at that temperature have been completed, or, in other words, that the alloy is in a state of equilibrium. The constitution of most of the important series of binary alloys has now been more or less completely worked out, and equilibrium diagrams of each of these series, in which the substances or phases that are in equilibrium in any alloy at any temperature, have been published. The constitution of the copper-zinc series of alloys was first satisfactorily explained by Shepherd* in 1904, and his results have been checked by others since, notably, Tafel,† with the result that Shepherd's equilibrium diagram has been proved to be correct in the main, and so far, at least, as the useful or yellow alloys are concerned, very accurately represents their constitution. That part of Shepherd's diagram which deals with the yellow alloys is reproduced in Fig. 1.

A reference to the equilibrium diagram will show that any alloy containing more than about 70 per

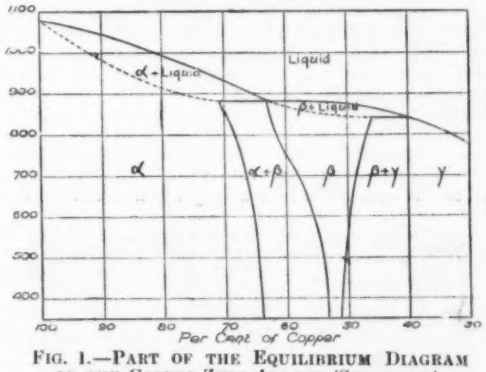


FIG. 1.—PART OF THE EQUILIBRIUM DIAGRAM OF THE COPPER-ZINC ALLOYS (SHEPHERD).

cent. of copper consists, when completely solid, of a single phase, a solid solution of zinc in copper, called α. Such alloys, when examined microscopically, after being polished and etched, are seen to have a dendritic or arborescent structure caused by cores slightly richer in copper than the rest of the solution in each of the crystalline grains. A long annealing will make the solution of perfectly uniform composition throughout, the cores will disappear, and the microscopic structure will be one of homogeneous crystal grains with very irregular boundaries. The same uniformity of composition is more quickly realised if the alloy is rolled before annealing, although the deformation due to the mechanical work causes very frequent twinning of the crystals.

In alloys of copper and zinc which contain less than 70 per cent. of copper, the influence of another substance besides the α solution must be considered. This is known as β, and is also a solid solution of zinc and copper, which at the ordinary temperature may contain between 51 and 53.5 per cent. of copper, but at the melting point may contain anything between 46 and 70 per cent. of copper. The β solid solution of

* It may be noted that certain liquids, as in the case of some organic compounds, are capable of assuming crystalline forms to which the name "liquid crystals" has been given.

† For this and other theoretical portions of the subject reference should be made to works such as Dr. Desch's "Metallography," Longmans, 1910, in the series of Text Books of Physical Chemistry, edited by Sir William Ramsay.

* Journal of Physical Chemistry, 1904, 421.
† Metallurgie, 1908, 5, 349.

copper and zinc is somewhat harder, and, when cold, much less malleable and ductile than the α solid solution, but it is fairly malleable when hot. The β solution, when examined microscopically, shows no cores in the crystals due to want of uniformity in composition, and rolling, hammering, etc., does not

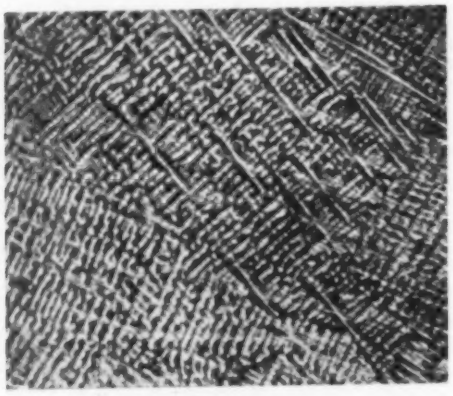


FIG. 2.—BRASS, 70% COPPER (CAST). α SOLID SOLUTION (DENDRITIC) MAGNIFICATION 50 DIA.; VERTICAL ILLUMINATION.

cause the crystals to become twinned. The properties of the β solution are thus quite distinct from those of the α solution. A brass containing between 70 and 64 per cent. of copper consists of α, together with some β, but this β is redissolved in the α at lower temperatures. The solution of the β in the α is a change that takes place somewhat slowly, and when cast these alloys always retain some of the β enmeshed in the α and accentuating the dendritic struc-

FIG. 3.—BRASS, 70% COPPER (ROLLED AND ANNEALED). α – SOLID SOLUTION (UNIFORM). MAGNIFICATION 100 DIA.; VERTICAL ILLUMINATION.

ture of the latter. Annealing, especially after rolling, enables the α completely to dissolve the β, and the structure and constitution of these alloys is then exactly the same as those with higher percentages of copper. The α solid solution of zinc (and similar solid solutions of other metals) in copper is strong, malleable, and ductile, and is specially suitable for rolling and drawing cold.

When the amount of copper is between 63 and 64 per cent. the alloy consists of a mixture of the two substances α and β under all conditions. The only change produced by varying the rate of cooling or by annealing is a difference in the relative amounts of α and β present. The α solution is capable of holding more zinc in solution at low temperatures than at high, while the β is not able to retain so much zinc in solution at low temperatures. Consequently, if equilibrium is maintained at all temperatures, the quantity of α present will increase, and the quantity of β decrease as the temperature falls.

Alloys containing between about 45 and 63 per cent. of zinc consist only of the β solid solution when just solid. Of these alloys only those containing 51 to 53.5 per cent. of copper preserve this constitution at all temperatures. When the copper is between 53.5 and 64 per cent., the β solution that crystallises from the molten alloy deposits crystals of α as the temperature falls, and hence, under normal conditions, these alloys consist of a mixture of α and β. This mixture of α and β is the constitution of alloys of the Muntz metal class, which are particularly suitable for hot rolling, the β solution being far more malleable when hot than when cold.

The two solutions, α and β, are easily recognised

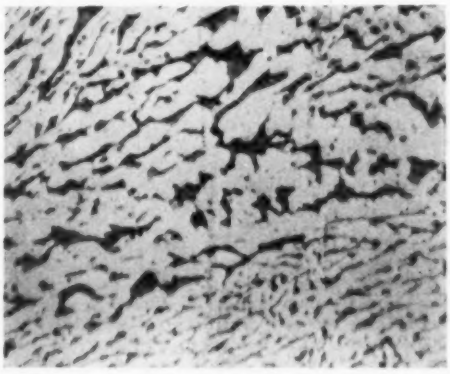


FIG. 4.—BRASS, 61% COPPER (CAST). MIXED α (LIGHT) AND β (DARK). MAGNIFICATION 200 DIA.; VERTICAL ILLUMINATION.

under the microscope, as one or other of them (usually β) becomes stained or darkened by the etching agent before the other is affected, or, if the etching process is carried out so as to leave the entire surface clean and free from stain, then a marked difference in colour (α reddish-yellow, β greenish-yellow) serves as a distinguishing characteristic. The micro-structure shows a mixture of α and β arranged in more or less distinct areas or grains, which represent the original crystals of β. On rolling the α and β crystals become broken up and intermingled, and subsequent annealing causes a regrowth of crystals, the α and β becoming more uniformly mixed and without any trace of the original large crystal grains. The best alloys of this class contain an excess of α, and those with an excess of β have, if the alloys are of copper and zinc only, inferior mechanical properties. Brasses consisting of an excess of β, or even of β only, are, however, widely used in the form of special brasses, such as Delta metal, sterro metal, manganese-bronze, etc. In such cases the addition of small percentages of other metals, such as iron, manganese, etc., seems to modify the β, giving it much increased strength and toughness.

When an alloy of zinc and copper contains less

than 51 per cent. of copper, the originally formed β deposits, as the temperature falls, crystals of another substance, possibly an intermetallic compound, known as γ, which is hard, white and brittle. Some of this exceedingly brittle γ separates between the β crystals, and the whole alloy is brittle and useless, except as a solder.

The general constitution of the yellow copper-zinc alloys has thus been outlined, and it now remains to consider the effect of other metals which may be present, whether added intentionally or present in the form of impurities. Of these metals the commonest are tin, lead, and iron. Tin, to the extent of about 1 per cent., seems to be dissolved in the brass, both α and β. But when present in excess of this amount it gives rise to a separate constituent, which is seen under the microscope as a light-blue material. This constituent is hard and brittle, and probably is a compound of tin and copper of the formula Cu_4Sn. Tin up to about 1 per cent. increases the hardness of brass without impairing to any extent its malleability, while at the same time it makes the alloy better able to resist corrosion under certain conditions. One of the best known alloys of this class is the Naval brass, containing 60 to 62 per cent. of copper and 1 per cent. of tin.

Lead, which is almost always present in brass, is

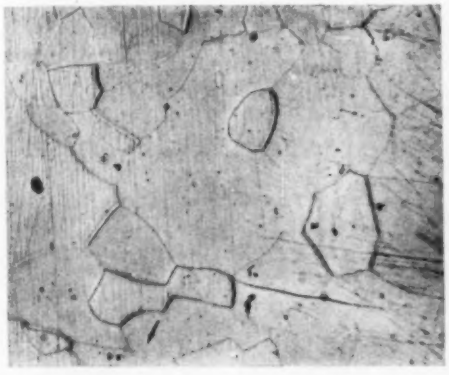


FIG. 5.—BRASS, 51% COPPER (CAST). β—SOLID SOLUTION. MAGNIFICATION 40 DIA.; VERTICAL ILLUMINATION.

not held in a state of solution or combination in the solid alloy, but is present in the free condition. It is therefore usually recognised readily when the brass is examined microscopically, being seen as small round particles or streaks. Owing to its very low melting point, the lead remains fluid long after the rest of the alloy is solid, and so it tends to form a film or layer round the brass crystals. Except in very small amounts lead thus impairs the strength and malleability of brass, but most brass contains 0.1 or 0.2 per cent. of lead, which is introduced as an impurity in the spelter. This small amount of lead does not seriously injure the mechanical properties of the brass, and common brass for castings may safely have more than this amount. Although much lead lowers the strength and ductility of brass, it serves a very useful purpose in some alloys, as it very much improves the turning qualities, and brass containing about 60 per cent. of copper (usually a little less) and about 2 per cent. of lead is largely manufactured as "turning metal." With more than 2 per cent. of lead the metal is inferior, and difficult to roll.

The use of iron and manganese in brass has already been referred to. This class of alloys includes Delta metal, sterro metal, Durana metal, manganese-bronze, and many other similar alloys with special trade names. They usually contain between 55 and 60 per cent. of copper, with 1 or 2 per cent. of iron, and sometimes small amounts of manganese and aluminium. The iron, aluminium, and manganese enter into solution, and the alloys consist of α and β, in which the β predominates, or even of practically nothing but β. Brasses of this character have often exceptional strength and toughness, as well as resistance to corrosion, and are being increasingly used.*

In addition to the metallic or other impurities or additions, brass usually contains some mechanically intermingled substances, such as zinc oxide, which, if present in unusual amounts, may have a harmful effect on the properties of the alloy, causing weakness and sponginess. The presence of dissolved gases in the molten alloys may also have a very injurious effect on their properties, since if liberated during the process of solidification, they cause sponginess and intercrystalline weakness. Any exact knowledge of the behaviour of such impurities as oxide and gases in brass alloys is very limited, and the probable importance of their influence is not always realised.

In concluding this Paper a classification of the useful brass alloys, according to their composition, may be given.

(1) α *Brasses.*—Alloys consisting of the α solid solution only. They include the most ductile brasses, such as the 70.30 alloy.

(2) α, β *Brasses.*—Alloys consisting of about equal quantites of the solid solutions α and β, or those in which the α predominates. These brasses are suitable for hot rolling, and include such alloys as Muntz metal. Special alloys containing tin or lead, such as Naval brass and turning metal, belong to this class.

(3) β *Brasses.*—Alloys consisting of β only, or mixtures of α and β, in which the β predominates. These alloys almost always contain small percentages of iron, manganese, or other metals, and include special brasses, such as Delta metal.

Theory of Malleableising.

By W. H. Hatfield, B.Met., A.M.I.Mech.E. (Sheffield).

As is now well understood, there are two distinct systems of malleablising; the first is known as the Reaumur, or European, process, and the second is known on this side of the water as the American Blackheart process.

The Reaumur Process.

This process is generally understood to depend upon the principle of decarburisation, but as the author demonstrated before the Iron and Steel Institute last year,† it is really more complex. Until recently the theoretical considerations underlying this method were very imperfectly understood, but the research work of

* Very full information on the constitution, structure, and composition of the brass alloys is given in "Alloys" by E. F. Law Griffin, 1909.

† Journal Iron and Steel Institute, vol. i., 1903.

recent years upon the iron-carbon system has greatly assisted to a solution. As cast, the material is intensely hard and microscopically consists largely of the hard constituent cementite or carbide, and it will be appreciated that this constituent must either be eliminated or destroyed before the casting can acquire the property of malleability.

The author has published* a set of experiments designed to indicate the actual changes taking place

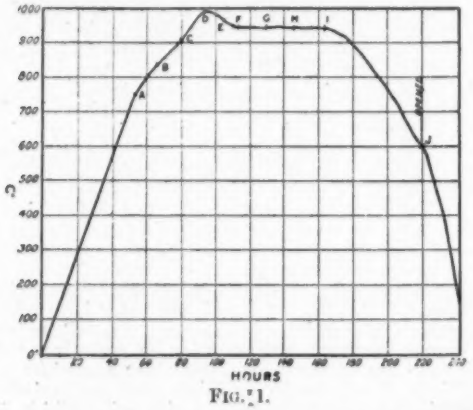
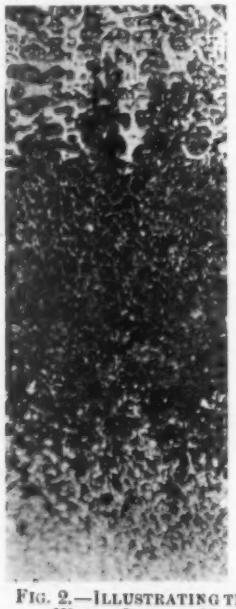


FIG. 1.

during the process, and he thinks it may be useful here to reproduce them. The analysis of the castings used was typical of that employed by most producers of this material:—Combined carbon, 3.5 per cent.; graphite, nil; manganese, trace; silicon, 0.50 per



Cementite-pearlite structure of white iron: combined carbon per cent., 3.00.

Carbon equal to slightly super-saturated steel.

Saturation 0.80 to 0.90 per cent.

Pearlite with ferrite increasing.

Skin of ferrite.

FIG. 2.—ILLUSTRATING THE DECARBURISATION OF WHITE IRON. MAGNIFIED 130 DIAMETERS: ETCHED (HNO_3.)

cent.; sulphur, 0.35 per cent.; phosphorus, 0.05 per cent.

The oven was taken through the heat treatment curve illustrated in Fig. 1., and samples were taken at the times indicated by the letters A to I, and allowed to cool in air. To metallurgical students the advantage of this method will be obvious. The castings were packed with hematite iron ore. Microsections were prepared from each test piece, and in this manner were the progressive changes observed.

Sample A.—Practically the whole section consists of the cementite-pearlite structure of the hard castings, but a thin skin is apparent from which the carbide had been removed.

Sample B.—Almost identical except that the decarburised skin was increasing in thickness.

Sample C.—The skin is now much thicker and is seen to be outwardly composed of ferrite, which changes gradually to pearlite, after which the cementite of the hard interior is reached.

Sample D.—The skin is still thicker. The decarburisation has penetrated at least $\frac{3}{16}$ in., but the microstructure is little altered otherwise, and is shown in Fig. 2. No free carbon is noticed. The upper portion in continuity with the centre of the casting is obviously still unchanged. If the photomicrograph is traced downwards, this the cementitic structure abruptly terminates, giving place to a structure similar to that of slightly supersaturated steel, which in turn is replaced by a purely pearlitic range, and then comes the ferrite progressively increasing until the ferritic outer edges are reached.

FIG. 3.—ETCHED (PICRIC ACID). MAGNIFIED 120 DIAMETERS.

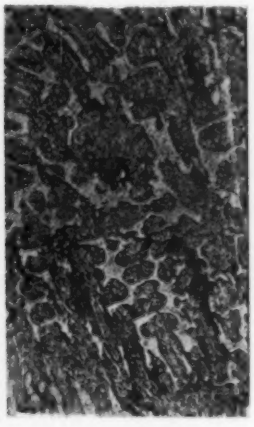


FIG. 4.—ETCHED (PICRIC ACID). MAGNIFIED 120 DIAMETERS.

Sample E.—A great change has taken place; the cementite in the central portion has disappeared and is replaced by a matrix equivalent to high-carbon steel in which is to be observed the "annealing carbon" produced by the dissociation of the carbide.

Sample F to I.—There is very little further change with the exception that the decarburisation proceeds towards the centre of the bar and the annealing carbon appears gradually to decrease in size.

Sample J.—The centre consists of well laminated pearlite, containing the annealing carbon, merging into the well-developed ferrite of the skin.

This final material was really good Reaumur malleable cast iron and analysed as follows:—Combined carbon, 0.65 per cent.; annealing carbon, 1.10 per cent.; sulphur, 0.35 per cent.; phosphorus, 0.05 per cent.

It will be seen that during the annealing two distinct processes were at work—(1) Elimination by oxidation; (2) softening by precipitation of annealing carbon.

* Journal Iron and Steel Institute, vol. i., 1909.

The feature of interest is that the decarburisation was the first phase of the change, whilst the breaking down of the carbide was a later development.

As a result of these and supplementary experiments the author expresses his views of the chemical physics involved as follows:—

> The carbon is eliminated whilst still in combination with the iron. At the comparatively low temperature of 750 degrees C. this reaction begins to take place between the carbide of iron and the oxidising medium. The activity of the elimination gradually becomes greater with the increase in temperature, until a temperature is reached at which, according to the composition of the iron, the precipitation of annealing carbon takes place until equilibrium for that temperature is established. Previous to this precipitation the iron consists of a decarburised exterior, with the interior still retaining the original quantity of combined carbon.
>
> After precipitation there is still a decarburised exterior, but in the centre a composition equal to saturated or slightly supersaturated steel, in which the precipitated temper carbon is contained. The carbon now in solution would appear to diffuse outwardly to the skin to replace the already eliminated carbon. As in this manner further combined carbon is removed from the iron, so is the equilibrium maintained by the absorption or solution of more annealing carbon to fill its place. The diffusion or absorption of temper carbon in this manner was recorded earlier in this Paper, and the fact that on the completion of the softening of this material considerable quantities of annealing carbon remained, would seem to give complete confirmation to this explanation.

The chemical reactions of the process may therefore be expressed somewhat as follows:—

1st stage (decarburisation)—

$$2\,Fe_3C + 2\,CO_2 = 3\,Fe_2 + 4\,CO.$$
$$2\,CO + O_2 = 2\,CO_2$$
$$2\,CO_2 + 2\,Fe_3C = 3\,Fe_2 + 4\,CO$$ } Continuous.

2nd stage (precipitation)—

$$2\,Fe_3C = 2\,Fe_3 + C_2.$$

The Blackheart Process.

The American Blackheart process is somewhat different, although in principle there is more similarity between it and the Reaumur process than is at first apparent. The composition of the American irons are such that the carbon can consistently be precipitated with more completeness, and the result is the well-known black fracture of the castings. The well-known steely appearance of the European material is due to the retention of a small percentage of the carbon in combination. In a Paper read* in 1907, the author published a set of micrographs illustrating the reactions of the blackheart method, and it will be seen that they do not depend upon the principle of decarburisation.

Fig. 3 illustrates the structure of the material used and it will be noted that it is the normal cementite pearlite structure of white iron; its analysis shows it to contain:—Combined carbon, 3.4 per cent; graphite, nil; manganese, 0.14 per cent.; silicon, 1.10 per cent.; sulphur, 0.06 per cent.; phosphorus, 0.04 per cent.

The castings were heat-treated in a large annealing oven, and test bars taken at different periods, as described in the former experiments. The microsection of the sample taken when approaching 800 degrees C. (Fig. 4) indicated curiously that a slight diffusion of the cementite had already taken place. This was unexpected, but has since been confirmed.

The next sample (Fig. 5), taken some hours later at 820 degrees C., showed that the precipitation had already commenced, but after another 48 hours it was found that most of the carbide had been broken up. Fig. 6 shows the microstructure at the latter period.

The heat treatment was then completed and a test bar taken after cooling down to 750 degrees indicated (Fig. 7), that the whole of the carbide of supersaturation had gone, and it is reasonable to suppose that had the bar been perfectly quenched would have consited of hardenite with the annealing carbon involved. Fig. 8 represents the microstructure obtained upon cooling to 650 degrees, *i.e.*, below the pearlite change point. It is therefore correct to deduce that as this bar only contains ferrite and annealing carbon, the carbide of the pearlite must have decomposed im-

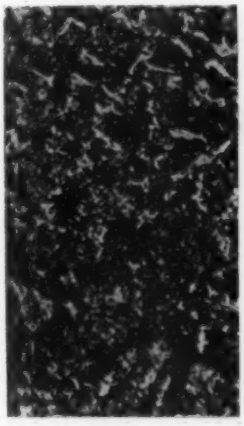


FIG 5.—ETCHED (PICRIC ACID). MAGNIFIED 120 DIAMETERS.

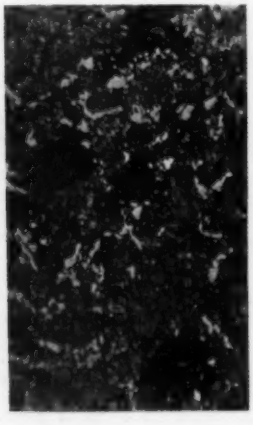


FIG. 6.—ETCHED (PICRIC ACID). MAGNIFIED 120 DIAMETERS.

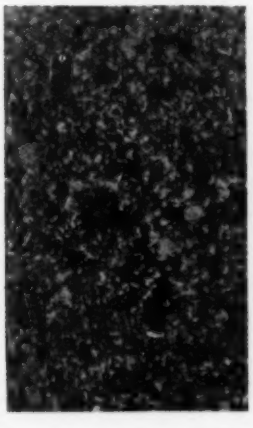


FIG. 7.—ETCHED (PICRIC ACID). MAGNIFIED 120 DIAMETERS.

FIG. 8.—ETCHED (PICRIC ACID). MAGNIFIED 120 DIAMETERS.

* Iron and Steel Institute Journal, 1907, vol. ii.

mediately upon the resolution of the latter. This, it is considered, illustrates the reactions of the black-heart process, and the following analysis of the completed material will possibly be of interest:—Combined carbon, 0.05 per cent.; annealing carbon, 2.60 per cent.; manganese, 0.14 per cent.; sulphur, 0.06 per cent.; phosphorus, 0.04 per cent.; silicon, 1.10 per cent.

The President suggests that the paper should not be too long, otherwise the subject might be treated at somewhat greater length. Suffice it, that it must be stated that in each process there is considerable latitude in the composition of the material, and that with each change in composition the heat treatment must be accordingly modified.

At some future date the author would like to deal further with the influence of this varying composition.

As an indication of the results obtainable by these processes of malleablising, a number of samples prepared by the author and Mr. John F. Crowley (Messrs. J. Crowley & Company, Limited, Sheffield), which may be of interest to the members, are placed on the table. When one considers that the base of malleable cast iron is an iron with 3 to 4 per cent. of carbon of a melting point of only 1,150 to 1,200 C., the meeting will no doubt agree as to the future before the industry. The author in works practice obtains from such material a maximum stress of 20 to 25 tons to the square inch, accompanied by an elongation of 10 to 15 per cent.

The Electric Furnace.

By W. S. Gifford, Assoc.R.S.M.

The electric steel furnace has been causing so much interest of recent years, and so many papers and articles have been written about it, that it is difficult to say anything original on the subject. There is one of its uses, however, which has been comparatively neglected in the technical literature of the day, although it is of great importance, and has been considerably developed in practice. I refer to its application for making castings; and the object of this Paper is to give an idea of what has been done in this direction.

The use of the electric furnace in the foundry has long since passed the experimental stage, and British foundrymen must now consider it as a process which is accepted on the Continent, and with which they must reckon in England in the near future. It has been to some extent assumed in this country that it can only be economically adopted in places where the proximity of water power makes electricity extremely cheap, but it must be remembered that cheap power is less important to the steel maker than accessibility, and the two are seldom found together.

The various types of electric furnace have been described so often that it would serve no useful purpose to go over the ground again. I will therefore only take one furnace which has been adopted by many more firms in England, America, and the Continent, than any other, and mention some of its main points. The Héroult furnace is not a complicated electrical contrivance, but a simple tilting basic open hearth furnace in which the heat is applied by electricity instead of by some fuel which is bound to introduce sulphur and gas. The bottom is lined with dolomite, and the roof with silica, and any man who can line a basic furnace can do this work on the electric furnace. The electrodes are moved up and down by an automatic regulator, and consequently there is very little labour required.

The cost of repairs is very low. The roof lasts from 100-130 heats for refining molten steel. The cost of repairing a roof for a 2½-ton furnace is £3, which amounts to about 2½d. per ton of steel. The bottom is merely fettled with dolomite between the heats, the total cost for refractories being about 6d. per ton. These figures are obtained from South Chicago where a 15-ton furnace has been in steady operation for 15 months, refining molten steel from a Bessemer converter and turning out about 15 heats every 24 hours. The electrode consumption amounts to 6 lbs. per ton in large furnaces, and 10 lbs. in a small furnace in Germany, which, at 2d. per lb. (the cost of manufacture being less than 1d.) is equal to from 1s. to 1s. 8d. per ton of steel. The idea, by the way, that with an arc furnace it is impossible to make a low-carbon steel owing to the carbon from the electrodes getting into the metal is quite erroneous. There is no difficulty at all in keeping the carbon contents down to 0.03 per cent.

In places where the cost of power is high enough to make its consumption a matter of prime importance, the most economical method is to take molten and dephosphorised steel from a basic-lined furnace, preferably of a tilting type, and remove the gases and sulphur in the electric furnace. Even when using the commonest raw materials the sulphur can be brought down to below 0.02 per cent. and the gases completely removed in the Héroult furnace for a power consumption of from 100-150-kw. hours per ton, which, at a rate of 0.6d. per unit, works out at from 5s. to 7s. 6d. per ton. This expense, together with that for labour, repairs, electrode consumption, etc., can, as a rule, be more than counterbalanced by the saving in the cost of raw materials. The complete deoxidation is an especially important point, which is not generally sufficiently recognised.

Where power is cheap the whole process of melting and refining can be performed in the electric furnace. The procedure is then very simple. Lime and mill scale or iron ore are put in first, and scrap is added. The slag gradually works its way upward through the scrap, and by the time the steel is melted the phosphorus is removed. This oxidising slag is then skimmed off and the sulphur is removed by a basic slag. This slag is extremely basic and falls to pieces after teeming. The extreme reducing atmosphere of the furnace at this stage is shown by the fact that powdered charcoal put on the surface of the slag remains unburnt for a long time.

The arc on the lime slag forms calcium carbide, which in its nascent condition is very active in combining with sulphur. The presence of calcium carbide can be proved by putting a piece of slag in water, when a strong smell of acetylene is given off and the slag is seen to be white in colour.

The power required for melting and refining common scrap to 0.02 S. and P. in this way is about 750-kw. hours per ton. For intricate castings the great fluidity of the steel, owing to its complete deoxidation, is very advantageous. Castings of less than 1/25 in. in thickness have been made in Ger-

many for æroplane radiators. Another point is that the amount of gits can be decreased. Owing to the extreme reducing atmosphere of the furnace the addition of numerous deoxidising agents and other sorts of physic are avoided, so that more homogeneous castings are made, and there are fewer wasters and blow holes. The product obtained either by melting cold scrap or refining open-hearth steel is of the quality of good crucible steel, so that the advantage of the electric furnace over the open-hearth is that it produces a superior steel for the same price.

In comparison with the crucible process the gain of the electric furnace is one of cost. In this case there is a very large saving when making castings, as the cheapest raw materials can be used and the cost of pots is eliminated. In addition to this economy, amounting to several pounds per ton, there is a further saving in the process. The cost of melting in the open-hearth and refining in the electric furnace is considerably less than that of melting in crucibles. In the case of one steel foundry in England which is engaged principally in making cycle parts and other intricate small castings, where the crucible process, working on the best raw materials, has always been used, an electric furnace is now being erected to replace it entirely. In Germany this has been done in many places, and a marked reduction in costs has been effected, while the castings are in no way inferior to those previously made from the best crucible steel.

For the manufacture of heavier castings, where the margin of profits is much smaller, each case requires careful individual consideration. A short refining process in the electric furnace may often be adopted advantageously, for removing the gases. In such a case complete deoxidation with partial refining can be obtained for about 100-kw. hours per ton. The cost of this treatment is often counterbalanced by the smaller proportion of wasters, and the decrease in the number of gits and runners.

Some tables are appended showing the analyses of steels made by the Hèroult process, and the consumption of power both in refining alone and in melting and refining.

TABLE I.—*Refining Molten Steel from Bessemer Converter.*

Five consecutive heats.

Weight of charge. Tons.	cwt.	qrs.	K.W. hours.	K.W. hrs. per ton.
12	10	0	1,300	115
12	13	2	1,300	113
12	8	1	1,090	89
12	6	2	1,560	134
12	10	2	1,200	106

Average ... ... 111 K.W. hours per ton.

TABLE 2.—*Melting and Refining Common Scrap without Pig Iron.*

Five Consecutive Heats—

Charge (Scrap). Tons.	cwt.	Product. Tons.	cwt.	qr.	Time. Hr.	Min.	K.W. Hrs.	K.W.Hrs. per ton.
2	9	2	8	2	4	40	1680	686
2	9	2	5	3	5	00	1800	735
2	9	2	5	3	5	30	1980	809
2	9	2	6	1	5	15	1890	771
2	9	2	5	3	5	05	1830	747

Average ... ... 750 K.W. Hrs. per ton.

TABLE 3.—*Analyses of Steels in Table 2.*

C.	S.	P.	Mn.	Si.
0·86	0.014	0·011	0.31	0·23
0·85	0.013	0.020	0.31	0.23
0.95	0.013	0.017	0.14	0.25
1.00	0.012	0.016	0.18	0.16
0.85	0.013	0.003	0.16	0.17

Developments of the Gronwall Furnace.

At Sault Ste. Marie, Canada, a Chicago syndicate controls large deposits of ferro-nickel ore and also copper-nickel ore. It is proposed to erect three Gronwall shaft furnaces of 2,500 h.p. each at Sault Ste. Marie for working ferro-nickel direct from the ore. The pig-iron will contain about 10 per cent. of nickel.

The Gronwall shaft electric furnace, as used at Domnarfvets, has been already described in our columns. It is similar to those being erected at Trollhatten in Sweden, where two 2,500-h.p. furnaces are now being built by the Swedish Government, and will be ready by next July. As the water power already exists at Sault Ste. Marie, and the hydraulic works are almost completed, it is only a matter of putting in the generating plant and transmission lines. The same Chicago syndicate also propose to roast the copper-nickel ore and then treat the matte in Gronwall refining furnaces of about 600 h.p. each. The product obtained will be the so-called "Monel" white metal which has lately been extensively used in the United States. It has great resistance against corrosion and is taking the place of aluminium and zinc alloys. It is also being used for roofing material. Its proportions are 68 to 72 per cent. of nickel, 1½ per cent. of iron and the balance of copper.

Unlike most alloys, in the smelting and refining the nickel and copper are not separated or extracted, but remain about the same proportions as in the ore. Therefore, being a natural alloy, it is cheap; in most alloys the expense is in first isolating the metals. The result is a wonderful tough metal, flexible and easily worked. It can be drawn, spun, seamed and polished, brazed and soldered. Besides its non-corrosive properties it is remarkable as having smaller expansion and contraction than copper. The following figures may be of interest:—

	Monel metal Grade C.	Grade D.	Medium Steel castings.
Tensile strength per sq. in.	70,000	85,000	70,000
Elastic limit	27,000	40,000	35,000
	Per cent.	Per cent.	Per cent.
Elongation in 2 inches ...	30	25	25
Reduction of area	35	25	30

Monel metal 1 inch rods.

	As rolled.	Annealed & Cold drawn
Tensile strength per sq. in. ...	100,000	110,000
Elastic limit	50,000	80,000
	Per cent.	Per cent.
Elongation in 2 inches	30	25
Reduction of area	50	50
	Monel metal.	Copper.
Co-efficiency of expansion	0.00001375° C.	0.00001666
Melting point	1360° C.	1084° C.
Specific gravity rolled ...	8.94	8.95
Weight per cubic in. ...	0.323 lb.	0.323 lb.

The Wadkin Mechanical Pattern Maker.

In the early part of 1905 we published illustrations and some particulars of the mechanical wood-worker made by Messrs. Wadkin & Company, of Leicester. Striking tribute to the value of this machine in the pattern-making shop was paid recently, in a paper read by Mr. A. N. Spencer, of the Oliver Machinery Company, Mich., U.S.A., before the American Foundrymen's Association, and it may be advisable to bring the modern machine before our readers.

In its general appearance the machine, which is shown in Fig. 1, has changed very little, although as its latent capacities displayed themselves and became more evident, various parts were carefully considered, developed, and improved; and it has become the practice of the makers to review the machine from time to time, and by combining, wherever possible, several features in one device, to further increase the range of the machine, while reducing and simplifying the parts. Though an operator quickly grasps the general working of the machine, the extent of its operations is only more fully realised after a little time, as he gradually

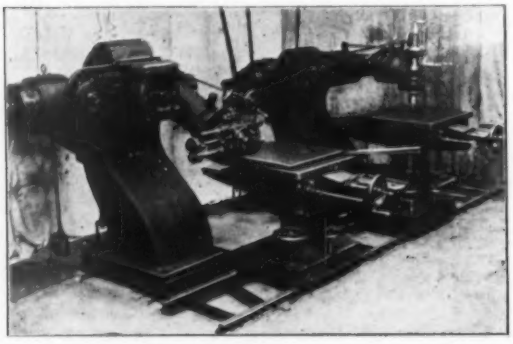


FIG. 1.—THE WADKIN MECHANICAL PATTERN-MAKER.

becomes aware that the flexibility of the machine renders its range of operations practically unlimited and simplifies and cheapens to a great degree the intricacies and difficulties of pattern work and other wood-working operations. Its sensitive balance and adjustment combined with its rigid and powerful construction render it equally capable of dealing with the delicate and intricate pattern work obtaining in some shops, as with the larger and heavier work of other shops. Its construction renders it quite free from vibration, and it is noiseless, being entirely free from gears. The drive, in all cases, is a variable speed with reverse, and either direct by motor carried on the back of the machine, the motor spindle driving direct on to the cutter spindle, or the drive may be intermediate by a reversible and variable speed motor driving on to the back shaft of the machine from any convenient position; or belt-driven direct through the variable speed auxiliary countershaft. Whilst operating in either vertical, horizontal, or any intermediate angular position, the spindle speed can be varied within a range of from 1,250 to 3,600 revolutions per minute, and the direction of rotation reversed instantaneously, the highest spindle speed being attainable without any vibration of the head. The flexibility of the belt drive is widely recognised as being the most suitable for withstanding the sudden shocks inherent to all timber-working operations. The cutter spindle has free-feed movements, either by a quick-acting positive variable lever, or sensitive screw feed, entirely independent of any movement of the head.

The slow feeds are capable of such fine regulation that a thin pencil or gauge line can be cut in two,

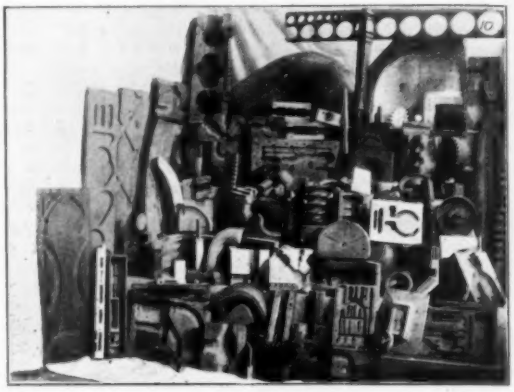


FIG. 2.—PATTERNS MADE ON THE WADKIN MACHINE.

a degree of accuracy fine enough for the most particular of pattern work. Particular attention should be given to the fact that the cutters are for the most part of simple fly pattern, and that the range of operations possible on the machine arises from the great variety of positions of the tool relative to the work, and not by any specially complicated pattern of cutter. The rocking arm in which the spindle head is rotatably mounted, is of great range and so sensitively balanced in its trunnions that practically no power is required to raise or lower it, and this sensitive balance allows of the manipulation of difficult, irregular-curved face work, enabling

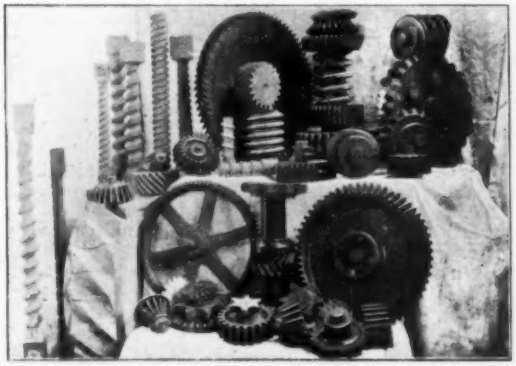


FIG. 3.—PATTERNS MADE ON THE WADKIN MACHINE.

core-boxes and other work with curves and shapes of a compound nature to be easily operated. Another important feature is the rigidity and range of movements of the table, which, in addition to a wide range of independent longitudinal and cross movements has a considerable vertical adjustment, and can be turned horizontally through a complete circle, combining rapid right angle, longitudinal, cross and circular movements, whereby it is enabled

to be moved circularly, lengthways, crossways or at any angle relative to the spindle, at the will of the operator, all of the said table movements being provided with quick adjustable stops.

The illustrations herewith serve to show the machine, and, to some extent, its flexibility. In Fig. 1 two machines are shown on their foundation frames, one motor and one belt-driven, under test. With each machine a general equipment and a full range of cutters, mostly on the expanding principle, may be supplied, to suit any particular kind of work to be done.

It may be mentioned that the machine will be shown in operation at the forthcoming Engineering Exhibition at Olympia, from September 1 to 26.

The F.T.J. Bookshelf.

General Foundry Practice.

By William Roxburgh, M.R.S.A. London: Constable & Company, Limited, 10, Orange Street, Leicester Square, W.C.

We have here, a practical foundry manager presenting in book form a collection of facts on general foundry practice—a compilation resulting from long experience in the foundry trade, and one cannot but express appreciation at the publication of such a work. Mr. Roxburgh's book cannot be classed as a complete text-book on foundry practice, but rather as a series of articles dealing with matters important to the foundryman and the engineering profession in general. The treatment of the cupola, for instance, is confined to a short opening chapter on the starting of a small iron foundry, in which the general requirements are outlined, while various other items do not get the orthodox text-book treatment. But as against this, many matters are considered more fully from the point of view of actual foundry practice. In this connection, a brief summary of the contents may be interesting. After instructions on the preparation of moulding sands, the location of impurities in castings is considered, followed by useful notes on such matters as core-gums, blow-holes, the burning of castings, venting, the use of risers, chaplets, shrinkage, the pressure of molten iron, the feeding or compression of metals, metal mixing, temperature and its effects, etc. An instructive portion treats with the moulding of special pipes, and then a few pages are devoted to each of the subjects of core-clipping, machine and snap-flask moulding, moulding cylinders and cylinder cores, jacketed cylinders, core sands, moulding a Corliss cylinder in dry sand, pipe core making, chilled castings, flasks and moulding boxes, gates and gating. This concludes the first division of the book. The second deals with jobbing loam practice, describing and illustrating various classes of work in loam. The third division takes a line somewhat distinct from the usual run of ironfoundry text-books; it treats with the moulding and casting of the finer metals. Very useful general information on the starting of a small brass foundry is given, followed by sections on bronze work, casting speculums, aluminium founding, and aluminium castings and alloys; while some notes on malleable castings are also here given. Much in this division is extremely handy, particularly to those about to start brass and aluminium work; but, especially as regards the latter class of castings, the notes given must be taken as rather the experience of the author than as a comprehensive guide to aluminium practice—the casting of the non-ferrous metals is too big a subject to be fairly treated in a few brief notes. Practical metallurgy forms the subject-matter of a few further pages, and then follows an interesting article on pattern-making from a moulder's point of view, and stucco pattern-making. A few notes on foundry ovens and their construction, fuels, and foundry tools etc., conclude the book. As previously indicated, it is rather a collection of hints from a practical worker, than a complete foundry text-book, but is, of course, not to be depreciated on that account; foundrymen who give their experience in this way are all too few. But we should like to offer a suggestion, which will, perhaps, guide other foundrymen when placing their knowledge before the public; it is that before publication the work be carefully revised by a competent literary man. The crudities of the moulding floor vernacular are too apt to creep in, when discussing practical matters; and while, perhaps, passable under certain circumstances, somewhat mar the style of a technical book. The fact that some of the matter has previously been published by a trade paper, too, does not guarantee its immaculateness. We do not offer this suggestion in the nature of an unkind criticism, but with the consciousness that a practical man's experience is worth putting into really good English. We do not look for literary experts in the moulding shop, or in any other branch of the craft; but it is not difficult to find a good reviser for even a technical work. Usually, the worst editor for any work is its author.

Hand-Book for Iron-Founders.

London: The Frodair Iron and Steel Company, Limited, Fenchurch House, E.C.

This little publication contains a useful fund of information for ironfounders, concerning the mixing of pig-irons for castings, and other foundry matters. The compilers are well-known as specialists on the question of pig-irons, and their experience enables them to speak with authority. Condensed hints on the selection of iron for special castings, on cupola practice, blowing machines, chilled castings, cylinder castings, and various matters of concern to the founder are given, and in addition tabular matter relating to the melting capacities of cupolas, etc., making, altogether, a handy and valuable reference work that can be easily carried in the pocket.

Correspondence.

Cast Iron and Superheated Steam.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—After reading the extracts from contributions to the Journal of the American Society of Mechanical Engineers, published in your last issue, I was struck chiefly by the utter uselessness of the reports as an index of the suitability of cast iron for superheated steam valve and fitting work. It almost seems as if there is a conspiracy on the part of engineers against cast iron, and on the part of ironfounders who cater for their requirements, since in hardly any instance where cast iron has been put to any critical test do we find that it was of anything approaching the right and easily procurable quality.

Cast iron seems to be more abused than used by modern engineers. The reason of all this is inscrutable, for wherever it can be made to answer equally as well as steel, phosphor-bronze or Muntz's metal, or other special alloys in mechanical constructions, cast iron means a great saving in cost, and can be manufactured in the shape of sound castings much more quickly and with more certainty than these materials, and supplied from a much wider base.

The analysis of the fittings examined by Mr. Orrok

(FOUNDRY TRADE JOURNAL, page 417) is extremely difficult to understand. We are not given the whole of it, but there is enough stated to enable us almost to construct a complete analysis. Silicon and phosphorus are stated; manganese and combined carbon are indicated, the former being given as "low" and the latter as almost absent. A low manganese would be, say, not exceeding 0.5 per cent., and an iron "essentially open in character" (see report), and containing almost no combined carbon may be taken as holding a high percentage of carbon, of course, all graphitic. Sulphur would almost certainly be low in such a high silicon mixture. We may therefore estimate the analysis as follows:—

	Per cent.
Carbon	3.75
Silicon	1.88 to 2.33
Sulphur	0.05
Phosphorus	0.70
Manganese	0.50

Now, what is there in the above analysis to yield a hard, good, strong, durable cast iron? My view is that an engineer putting important castings on his plant, of an iron of that kind, deserves to lose his reputation, and an ironfounder making them deserves to lose his business. It is an excellent analysis for stove-plate or iron railings, but for valves, cocks, etc., or steam fittings or cylinders of any kind it is perfectly useless.

I do not wish to be unfair, and will admit the possibility that the maker of these castings worked on some sort of principle; but the only principle I can excogitate is that it is supposed to represent a heat-resisting iron. I myself am very doubtful whether for heat-resisting purposes any analysis in iron can counterbalance the advantages of high specific density and hardness, providing only that phosphorus is kept within reasonable limits; and it is quite certain that these two characteristics are not to be had in any iron of the above analysis. But if this was the principle governing the selection, the purely chemical theory of heat-resistance as published in text-books might be said to have been fairly well followed, excepting as regards phosphorus; for it is difficult to see, if heat-resistance was the prime aim, why the phosphorus was permitted to stand at 0.7. It has, however, never been a demonstrable proposition that the disintegration of iron castings by superheated steam is the result of a heat action, and it is difficult to see that the greatest superheated steam temperatures are sufficient even to attack the phosphide eutectic, let alone the iron-carbide system in any sample of cast iron. The strain due to varying temperatures is a different question, and it seems that to resist the expansions or contractions due to these and the erosive or penetrating action of the superheated steam, it is just worth while trying a much harder and more tenacious material than can possibly be expected in an iron high in silicon, free from combined carbon and low in manganese and sulphur. Until such tests have been made it is most prejudicial to the ironfounding industry that reports should be published of cases where cast iron has failed for superheated steam work, and, further, whilst such reports are rife it is surely the ironfounder's duty to use something other than his ordinary silicious foundry mixture when he gets orders for superheated steam castings. That policy is incredibly short-sighted. For many present-day castings, such as cylinders, valve seats, piston-rings, etc., which have to stand heavy wear and stresses, the best founders are (or ought to be) using a far better material than that described in your columns. They will keep silicon at a much lower figure and use the hardening elements, such as manganese and sulphur much more freely, and will pay strict attention to the total carbon content. Surely, then, when new demands are made upon them as craftsmen in connection with steam superheating (a rapidly growing business), carrying, if anything, a more rigorous specification, they will see that the best possible iron is used for the work.

I would suggest for superheated steam valves, etc., a mixture of the following (base) analysis at charging door, modifiable according to section of the casting:—

	Per cent.
Silicon	1 25
Sulphur	0.08
Manganese	1.00
Phosphorus	0.60
Total Carbon	3.40

Yours faithfully,
JOHN F. R. LEWIS.

Queries.

Chilled Rolls.

(1) We have a chilled roll to make weighing 3½ tons. The length of body, which requires to be chilled to a depth of 1½ in., is 3 ft., and the diameter 26 in. Will any reader be good enough to tell me what thickness to make the walls of the chill into which to cast the roll?

(2) A few years ago a chilled roll which had fractured during cooling, was brought to my notice. The roll weighed 30 cwts., and the diameter of the body was 20 in. The fracture extended from bottom to top of the body, opening out about ½ in. and penetrating about ¾ in. The walls of the chill into which the roll was cast were 6 in. thick.—Query: Was the fracture due to the solidified and chilled surface of the roll being remelted by radiation of the internal heat, due to the iron chill not being of sufficient thickness to absorb the heat which radiated from the interior? In my opinion it was, and I expressed it so, whereupon I was told that the foundry in question had cast rolls successfully and others as the one described, using the same chill. This led me to think the composition of the iron (only irons considered within the range suitable for chilled-roll making) from which the successful rolls were cast, must have been extremely low in properties which make iron hot and fluid, and consequently poured at a very low temperature. I have no proof whatever that it was so, and I may be altogether wrong, but if any reader who has had practical experience upon this special class of work (I know there are many such), would kindly tender the information asked for, it would not only be greatly appreciated by myself, but would be of benefit to all those interested in the trade.

"SUBSCRIBER."

The Mixing of Metals.

Can any reader tell me of a book dealing with the mixing of iron for various classes of castings, such as cylinders (both for steam and gas engines), high-pressure pipes, pistons, piston rings, valves, etc., etc.; also the mixing of gun-metal, phosphor-bronze, brass and other alloys of a like nature?

"SEEKER."

Inventions.

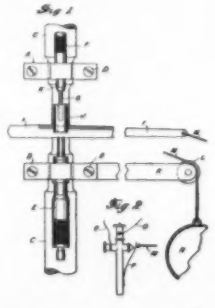
Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

17,238.*Crucible furnaces. W. Buess.
17,282. Casting metallic bodies under pressure and apparatus therefor. S. H. Hayward and A. D. McChristie.
17,650.*Electric furnace with a receptacle for the charge arranged on the enlarged furnace chamber. A. Helfenstein.
18,582. Treatment of moulds for metal castings. W. H. Putnam.
18,679. Direct production of iron or steel from iron oxide ores and furnaces therefor. W. S. Simpson and H. Oviatt, 173, Fleet Street, London.
18,777.*Anti-friction bearings. H. Stuebner, 285, High Holborn, London.
18,825. Furnace. G. S. Tunks and G. W. Jones, 33, Carlton Chambers, Newport, Mon.

Abstracts of British Patent Specifications recently accepted.

15,008 (1909). *Appliances for use in Testing Steel.* B. W. Winder, Continental Steel Works, Sheffield.—Figure 1 is an elevation of the device secured upon a piece of metal prepared for testing for its tensile strength; Figure 2 is a spring contact-maker to electric signal on reduced scale. It consists of two pairs of clamping jaws A and B constructed to grip at a suitable distance apart usually indicated by punch marks (not shown) upon the testing piece C, and secured in position by the screws D, which enable the jaws to be adjusted to test pieces of different sizes. One of the jaws carries a micrometer screw E, and the other jaw a facing piece F which may be either fixed or removable. It is adapted to carry extension rods G of various lengths by means of a contractible chuck or nozzle H. The



Appliances for use in Testing Steel.

end of the rod fits into a block J, which is grooved across the lower end to receive the upper edge of a gauge-rod I, which is marked or graduated to any desired scale as well as being made to a pre-arranged taper. This gauge-rod I is connected by a cord M to a weight N, which may conveniently be passed over a pulley L carried by an arm K extending from the clamping jaw B, so that on elongation of the test piece and consequent recession of the faces between which the rod I is held it is drawn forward by the weight. Thus if the rod tapers $\frac{1}{16}$ part of an inch in a length of 10 in. and is graduated to a scale of tenths of an inch, a movement of the rod of $\frac{1}{10}$ will represent an elongation of $\frac{1}{160}$ of an inch. The micrometer screw or like screw is not used for measuring the elongation of the test piece. The movement of the gauge-rod and the cord M, Figure 2, releases the spring P sufficiently to give a signal.

9,163 (1909). *Direct Production of Iron and Steel from Oxide Iron Ores.* W. S. Simpson and H. Oviatt, 165, Victoria Street, London, S.W.—An ore charge is prepared by thoroughly mixing the iron oxide ore, ground or pulverized, with a suitable quantity of a chloride capable in the presence of iron oxides and silica of forming a silicate; such as the chlorides of sodium, potassium, calcium, magnesium, strontium, barium or aluminium, in a ground state. The quantity of such chloride required varies according to the particular chloride employed and the character of the ore under treatment. Under most conditions the chloride of sodium is the more convenient and economical, and the quantity required per ton of ore varies from 10 per cent. to 25 per cent. of the weight thereof, ores containing a high percentage of phosphorus or sulphur requiring more of the chloride than ores less impregnated with such impurities. Such ore charge must also be provided (if not already existing in adequate proportions in the ore) with a suitable quantity of silica or equivalent silicious material, and with an adequate quantity of one or more of certain bases, such as lime, magnesia, and alumina, in a ground state. In order to form a readily fusible slag it is desirable that the ore charge shall contain a sufficient quantity of such basic materials to equal about one and one-half times the weight of the silica present. And the quantity of silica in such ore charge, whether originally existing in the ore or whether added thereto for the purposes of this process, should approximately equal 60 per cent. of the weight of the sodium chloride employed. Since it is not necessary that the total silica present in the ore charge should exceed 60 per cent. of the weight of the sodium chloride, in treating ores already containing silica in appreciable quantities there is added only sufficient silica or silicious material to supply any deficiency in the proportions mentioned. The oxides of iron when subjected to adequate heat, out of the air, in the presence of silica and such a chloride (as for example sodium chloride) may be reduced to metal without the employment of carbonaceous reducing agents of any kind. Under suitable thermal conditions and in the presence of the oxides of iron and a silicious material the constituents of the above mentioned chlorides are dissociated with the simultaneous production of metallic iron. Thus with sodium chloride the silica of soda is formed and the synthesis thereof seems to be an essential factor in the process of reduction. In treating titaniferous ores, manganese dioxide is added, in the form of manganese ore or otherwise, to the ore charge, and thoroughly mix the same therewith. The quantity of such dioxide varies from 2 to 6 per cent. or upwards of the weight of the ore charge, according to the general character of the ore and its titanium contents.

18,962 (1909). *Treatment of Steel for Desulphurising and Deoxidising Purposes.* R. H. Wolff, 445, Broadway, New York, U.S.A.—The dephosphorised molten steel is taken from the basic converter or open-hearth furnace, and poured in a ladle charged with a basic desulphurising and deoxidising slag in the molten state. The slag may consist of one or more of the following, viz., lime, fluorspar, manganese ore, ferro-silicon, ferro-manganese, calcium carbide, silicide of calcium, ferro titanium or aluminium. This slag being at a high temperature, coming in contact with the molten dephosphorised steel, will precipitate or hasten the operation of desulphurisation and deoxidation, which will assist to carry the metal sufficiently long in the ladle to desulphurise and deoxidise the same, and allow sufficient time to charge the steel into any kind of electric furnace for the purpose of finishing and resting the same. The process of purification and refining being continued in the electric furnace, and the final rest of the hot steel in a non-oxidising electric furnace, will permit the gases to be absorbed by the slag which rises to the top.

Trade Talk.

Messrs. J. Hackett & Sons, of West Bromwich, have just started the manufacture of malleable-iron fittings.

Mr. W. H. Coward, engineer and machinery merchant, of Bath, trading as W. H. Coward & Company, has been adjudged bankrupt.

Mr. G. E. Sendell, 36, Walbrook, London, E.C., has been appointed receiver and manager of Andrew Handyside & Company, Limited.

Considerable damage was caused by a fire which broke out on July 30, at the Mill Road Iron Works of Messrs. Phillip Pierce & Sons, Wexford.

A receiving order has been made in connection with the affairs of Mr. W. H. Coward, engineer and machinery merchant, Bath, who traded under the style of W. H. Coward & Company.

The business of John R. Bird, Limited, engineers, 10, Morrison Street, Glasgow, has been sold to Mr. James Arrol, Kingsley, Craigendoran, who will continue it at the same address.

Mr. H. W. Bowden and Mr. W. Boby have entered into partnership as consulting engineers at Salisbury House, London Wall, E.C. Mr. Bowden also retains his offices at 30, Craven Street, Strand, W.C., for the present.

Messrs. Tetley & Company, engineers, of Salford, Manchester, have appointed Messrs. J. Parkinson & Company, Post Office Chambers, St. Nicholas Street, Newcastle-on-Tyne, as their sole agents for Newcastle and district.

A dissolution of partnership is notified in connection with Messrs. H. H. Portway, R. Hall, and A. W. Kibble, iron and brass founders, Halstead, Essex, who traded under the style of the Tortoise Foundry Company, so far as regards Mr. R. Hall.

Messrs. S. A. Wiseman, H. Tardy, and C. W. Thurdin, general engineers, trading under the style of the Small Tool Manufacturing Company, New North Road and Rushton Street, London, N., have dissolved partnership.

The tender of William Simons & Company, Limited, of Renfrew, to build a steel ladder dredger for the Panama Canal has been accepted. Messrs. Simons' tender was for £79,870, over 50 per cent. less than the only American tender submitted.

Messrs. James Wall & Company, edge tool manufacturers, Holborn Works, Dronfield, have converted their concern into a limited company, incorporated under the Consolidated Companies Act. The capital is £5,000, divided into 5,000 ordinary shares of £1 each.

Messrs. W. A. Walber & Company, of 38, Victoria Street, S.W., have ceased representing Messrs. J. H. Storey & Company, machine-tool makers, of Hatcham, S.E. The machine-tool and machinery department of the company's business is being extended.

The British Mining and Metal Company, Limited, Lloyd's Avenue House, Lloyd's Avenue, London, E.C., inform us that the statement that, jointly with two other firms, they have been appointed agents for the Primos Chemical Company, of Primos, U.S.A., for the sale of ferro-vanadium is incorrect. The British Mining and Metal Company, Limited, did not take up the agency.

A contract for two steamers for Glasgow has been allotted to Swan, Hunter & Wigham Richardson, Limited, while an Admiralty order for boilers has been booked at South Shields. Applications to tender for the construction of the new Canadian fleet have been sent in by three British firms, including Swan, Hunter & Wigham Richardson, Limited, and also by three Canadian firms of builders.

The Clan Line, Glasgow, has placed orders for four vessels with British shipbuilders for their Glasgow, Liverpool, and Eastern trade. The successful contractors are Alex. Stephen & Sons, Limited, Glasgow; Wm. Doxford & Sons, Limited, Sunderland; Sir W. G. Armstrong, Whitworth & Company, Limited, Newcastle; and Irvine's Shipbuilding and Dry Docks Company, Limited, West Hartlepool.

The London and Glasgow Engineering and Iron Shipbuilding Company, Limited, have been engaged for some time in making extensive alterations and improvements on their shipbuilding yard at Govan and engineering works at Lancefield Quay, in order that the capacity of the establishments may be increased. The scheme includes the enlargement of the engineering shops, and the laying down of new plant for the construction of turbine machinery of a large size.

The Tyne Brass and Copper Tube Manufacturing Company, of Jarrow, have lately completed a consignment of S.D. brass locomotive tubes for the Great Indian Peninsula Railway Company, which constitutes the largest shipment of brass tubes which has ever been sent from their works. The consignment in question consisted of 7,000 tubes, weighing over 85 tons, taken by lighter to Middlesbrough Dock, for shipment on board the steamer "Chanda." There are still 1,000 tubes to be further shipped.

Messrs. J. T. Eltringham & Company, South Shields, are at present building for the Holzapfel Marine Gas-Power Syndicate, Limited, a cargo vessel, which will be fitted with a set of high-speed six-cylinder vertical gas engines, made by Messrs. E. S. Hindley & Sons, Bourton, Dorset. The engines have double ignition, and are of 180 b.h.p., at 450 r.p.m. The gas plant is being supplied by the Power-Gas Corporation, Limited, Stockton-on-Tees. The vessel will be 120 ft. long, 22 ft. beam, and 11 ft. 6 in. deep.

The Bowesfield Steel Company, Limited, of Stockton-on-Tees, who specialise in the manufacture of black, galvanised, and corrugated steel sheets, have recently arranged for the installation of an additional plate rolling mill. This mill is to be electrically operated, and a contract for electrical machinery of 750 horse-power has just recently been awarded to Dick, Kerr & Company, Limited, of Preston and Kilmarnock, whilst the current will be taken from a sub-station established on the works' site by the Cleveland and Durham Electric Power, Limited.

Electro-Metals, Limited, the registration of which we notify in the current issue, are placing the "Elektrometall" (Grönwall, Lindblad and Stälhane) electric reduction and refining furnace on the British market, the patent rights having been acquired in the British Empire, the United States, Mexico, Japan, etc. The other business of the company includes the construction of carbon electrode works, gas plant and plate welding works, nodulising and sintering plant, ore separators, kilns for cement burning, the Ruggles-Coles dryers for drying coal, shale and ore concentrates, etc.

A deputation from the Parliamentary Committee of the Trade Union Congress, which was received on Wednesday by the President of the Board of Trade, laid before Mr. Buxton certain questions connected with the working of the labour exchanges upon which they desired further information. Mr. Buxton stated that the Advisory Trade Committees were being formed as rapidly as possible, and that within a short time ten out of the fourteen or fifteen would be established. He also dealt with the other questions which various members of the deputation brought before him.

A meeting of the creditors of the Midland Engineering Company, Birmingham, was held on July 22, at Birmingham, the liquidator, Mr. H. W. Brettell, presiding. The statement of affairs showed unsecured creditors, £2,461 0s. 6d.; reserve for contingent liabilities, £183 14s. 10d.; debts due to the company, £1,088 7s. 1d. estimated to produce £888 7s. 1d.; office furniture, plant, patterns, stock-in-trade, etc., £320; cash in hand at bank, £8 6s. 4d. Deduct preferential creditors, £60 12s. 9d., leaving deficiency of £1,488 14s. 8d. It was unanimously decided to leave the matter in the hands of Mr. Brettell.

The total make of pig-iron at the works of the Normanby Iron Works Company, Limited, of Middlesbrough, for the year ending June 30 last was 125,137

tons, which is the largest quantity that has ever been made at the Normanby Iron Works. The company had only two furnaces in blast up to the end of February last, and therefore the full plant was only at work four months. The average price realised was 4s. 8d. higher than the previous year, but Mr. A. F. Pease points out to the shareholders that the values of ore and coke, especially the former, during last year were very high in proportion to the market value of pig iron. Three furnaces at the present time are working satisfactorily, the make per week being about 3,000 tons.

The text was issued, on August 2, of a Bill to amend the Workmen's Compensation Act of 1906, presented by Mr. Baird, and supported by Mr. Pollock and Mr. Robert Brassey. The memorandum states that the measure proposed to deal with the admitted hardships entailed on elderly or physically infirm workmen under the Act in question, by enabling them to enter into a special agreement in respect of compensation. The Bill proceeds generally along the lines recommended in the report of the Departmental Committee appointed in 1904. It is made clear that the initiative is to be taken by a workman, and that an employer cannot proceed until he has received a written application from a workman, countersigned by the officer in charge of the Labour Exchange of the district, expressing his desire to enter into a special agreement.

Included in the contracts recently placed for new equipment for the Indian railways is a large order to Robert Stephenson & Company, Limited, of Darlington, for the supply of spare and duplicate parts for locomotives of the East India Railway, for which company Dorman, Long & Company, Limited, of Middlesbrough, have in hand for early delivery 5,500 tons of bull-headed steel rails. The order for the steel bolts and nuts for use in conjunction with these steel rails has been placed with the Anderson Foundry Company, Limited, of Port Clarence, Middlesbrough, who have also an order for points and crossings for the Burma railways. To the Darlington Railway Plant and Foundry Company, Limited, has been given a contract for the supply of switches and crossings for use on new extension lines of the South Indian Railway.

The Engineering Society of the City of Cardiff Technical School have decided to ask the Cardiff Technical School Committee to recommend the Association of Technical Institutions to take such action (in combination with employers, etc.) as will have for its objects the following:—(1) The adoption of a definite standard of educational attainment to be reached by all youths desirous of becoming apprenticed as engineers. (2) The adoption of a definite standard of educational attainment to be reached before anyone engaged in an engineering profession shall be recognised as a trained engineer. (3) The remodelling of the syllabuses of the Board of Trade for the examination of marine engineers in such a way that all candidates shall be required to successfully undergo during their apprenticeship a course of technical training approved by the Board of Education.

The Marquis of Graham, C.V.O., will formally open the Naval, Mercantile Marine, and General Engineering and Machinery Exhibition at Olympia, London, on September 1. The show promises to be one of exceptional interest to naval architects, shipbuilders, engineers, and machinists generally. Many of the latest inventions in connection with all branches of engineering practice will be on view for the first time. The exhibits comprise metallurgical processes and raw materials, castings, machine tools, shop tools and appliances, lifts, lifting appliances, contractors' plant, grinding and crushing machinery, tubes and fittings, transport plant, engineers' stores, fire appliances, packings, mechanical stokers and conveyors, warming, lighting, sanitary and ventilating apparatus, dockyard plant, and gas, steam, and oil engines, etc. Special meetings of several engineering and scientific societies will be held at Olympia during the period of the Exhibition.

A revised valuation tariff for use in assessing import duties on iron and steel manufactures imported into Egypt has just been issued. The tariff was to come into force on July 16, and is to remain in operation for a period of three months (*i.e.*, until October 15) or until denunciation. The valuation is per kilogramme, 1,000 millièmes equalling £E 1:—Iron and steel plates, ordinary, without mark, ¼ in. thick and upwards: British, 6 millièmes; Belgian and German, $5\frac{8}{10}$ millièmes; iron and steel bars and angles, and tees, and **U** ordinary without mark: British, $5\frac{4}{10}$ millièmes; Belgian and German, $5\frac{1}{10}$ millièmes; iron bars, Swedish, $10\frac{5}{10}$ millièmes; iron, pig, $3\frac{5}{10}$ millièmes; iron and steel hoops, $7\frac{3}{10}$ millièmes; iron and steel hoops, with holes, $7\frac{5}{10}$ millièmes; galvanised sheets (B.G., 16 to 26), $13\frac{5}{10}$ millièmes; galvanised corrugated sheets (B.G., 16 to 26), $12\frac{5}{10}$ millièmes; studs (Benwill's) new, $23\frac{1}{2}$ millièmes; studs (Benwill's) old, 20 millièmes; studs, small, 22 millièmes; nails (French), 15 by 35 to 24 by 200, $8\frac{7}{10}$; iron and steel girders: British, $5\frac{6}{10}$ millièmes; Belgian and German, $5\frac{3}{10}$ millièmes.

A few days ago the announcement was made that two schemes were on foot for the establishment of new industrial concerns at Barry. The principal of the two schemes is the establishment of steel and iron works on land about 100 acres in extent belonging to Lord Ashby St. Ledgers, at Sully, within convenient proximity to the Barry No. 2 Dock. The chief promoters of the Barry Steel and Iron Company are London gentlemen, the chairman being Mr. Mills, of the firm of Messrs. Glyn, Mills & Company, the well-known London bankers, and the secretary is Mr. Drundrett. It was in connection with this company that an application was considered by the Cardiff Waterworks Committee last week for a supply of 100,000 gallons of water per day for the proposed works at Sully, but, inasmuch as this portion of the Parish of Sully is within the Barry Council area, consideration of the application was deferred. The promoters of the other concern have taken thirty acres of land in the same locality, with the option of a further twenty acres. These works will be, it is stated, for the manufacture of steel.

Personal.

Sir Charles B. McLaren, Bart., M.P., recently left London for the Continent.

Mr. H. Adamson, of Sunderland, has been appointed assistant general secretary of the Amalgamated Society of Engineers.

The late Mr. A. Maxwell, of 8, St. James's Terrace, Glasgow, retired iron merchant, left personal estate valued at £28,002.

Mr. S. Doncaster has been elected a director of Samuel Fox & Company, Limited, in place of Mr. James Halliday, resigned.

Mr. Aneurin Williams, M.P., who recently underwent an operation in London, has returned to his home at Hindhead, and is now convalescent.

Mr. William Lionel Hichens has been appointed a director and chairman of Cammell, Laird & Company, Limited, of Sheffield and Birkenhead.

The gross value of the estate of the late Mr. J. W. Maud, Holme Dene, Halifax, of the firm of Maud & Turner, machine tool makers, is £11,768.

Mr. A. M. Carlisle, managing director of Harland & Wolff, Limited, Belfast, has decided to retire from active business in consequence of the state of his health.

The gross value of the estate of the late Mr. John Elwell, of Sunnydale, Knowle, Warwick, managing director of John Elwell, Limited, Birmingham, is £17,071.

The gross value of the estates of the late Mr. J. R. Turnbull, of 47, Calthorpe Road, Birmingham, metal merchant, is £26,656 2s. 7d., with £26,314 6s. 11d. net personalty.

The King has been graciously pleased to become Patron of the Institution of Civil Engineers, of which Institution he was an honorary member for 17 years before his accession to the throne.

Mr. P. M. Hampshire, assistant in the physics and engineering department of the Municipal Technical School, Blackburn, has been appointed as lecturer and practical instructor in engineering at the Municipal Institute, Walsall.

Mr. E. F. Atkins, a director of the American Westinghouse Electric and Manufacturing Company, has been elected president of the company in succession to Mr. George Westinghouse, resigned. Mr. R. Mather has been re-elected chairman of the Board.

Mr. Alex. R. Horne, B.Sc., A.M.I.Mech.E., at present assistant professor in the mechanical engineering department of the Heriot-Watt College, has been appointed as head of the new engineering department at Robert Gordon's Technical College, Aberdeen.

The late Mr. Alexander Sowerby Hay, of Salcombe Park, Ware, Herts, a director of the North-Eastern Steel Company, Limited, Dorman, Long & Company, Limited, and Bell Brothers, Limited, left estate of the gross value of £115,526, with net personalty £110,690.

The Council of the University of Sheffield have appointed Mr. A. E. Findley, B.Sc. (Birmingham), F.C.S., to the newly-instituted post of Lecturer of Applied Chemistry in the University. Mr. Findley is at present Assistant Lecturer in Chemistry at the Bradford Technical College.

The City and Guilds of London Technical Institute has awarded medals and prizes for proficiency in the subject of "Iron and Steel Manufacture" as follows:—First Honours: A. Spargo, Wednesbury Science Schools. Second Honours: L. Aitchison, Sheffield University. First ordinary: D. J. MacNaughton, South-Western Polytechnic London; second ordinary, F. C. Thompson, Sheffield University; third ordinary, L. G. Morgan, Llanelly County School.

Mr. R. E. Highton, J.P., of Workington, who has been for some time in indifferent health, has withdrawn from the directorate of the Workington Iron and Steel Company, Limited, and has been succeeded in the commercial and general management of the company's steel works department by Mr. Valentine Ellis, son of Mr. Joseph Ellis, managing director of the Workington Iron Works department. Mr. Highton, when the Moss Bay Company was merged in the combine last summer, became a managing director of the new concern.

New Companies.

Ferguson Superheaters, Limited.—Capital £5,000 in £1 shares (2,500 preference), to carry on the business of engineers, etc.

Metallurgo Syndicate, Limited.—Capital £2,000 in 2s. shares, to acquire from H. Krall the benefit of a secret process relating to the production of a new alloy.

Electric Furnaces and Smelters, Limited.—Capital £5,000 in £1 shares, to carry on the business of smelters, etc. Registered office: 110, Cannon Street, E.C.

Clegg Engine Syndicate, Limited.—Capital £5,000 in £1 shares, to acquire from W. H. Clegg certain British patents relating to internal combustion and other engines.

S. Strong & Company, Limited.—Capital £1,000 in £1 shares, to carry on the business of boilermakers, etc. Registered office: 135A, Bermondsey Street, Bermondsey, London, S.E.

Greenhill & Craig, Limited.—Capital £6,000 in £1 shares, to acquire the engineering business of Greenhill & Craig, Belfast. Registered office: 29-37, King Street, Belfast, Co. Antrim.

Buckman Engineering (Parent) Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of mechanical and general engineers, etc. Registered office: 2, Clement's Inn, Strand, W.C.

Harry Crossley & Company, Limited.—Capital £500 in £1 shares, to carry on the business of brass founders and finishers, etc. Registered office: Perseverance Works, 42, Corporation Street, Halifax.

Geo. Broad & Son, Limited.—Capital £5,000 in £1 shares, to carry on the business of brass and bronze founders, etc. Registered office: 41 and 42, Windmill Street, Tottenham Court Road, London, W.C.

Henry Edie & Company, Limited.—Capital £6,000 in £1 shares, to take over the business of brass and iron founders carried on by Henry Edie & Company. Registered office: 155, Fenchurch Street, London, E.C.

Hunt & Moscrop, Limited.—Capital £8,000 in £1 shares, to carry on the business of engineers, etc., and to acquire the business carried on at the Central Iron Works, Springs Street, Middleton, Lancs., by Hunt & Moscrop.

Russell & Company (Engineers), Limited.—Capital £2,000 in £1 shares (1,000 preference), to carry on the business of lighting, heating, and ventilating engineers, etc. Registered office: 9, Lancashire Court, New Bond Street, W.

Electro-Metals, Limited.—Capital £30,000 (4,000 preference shares of £5 each and 10,000 ordinary shares of £1 each), to carry on the business of engineers, etc., and to enter into an agreement with Jens Orten-Boving & Company.

Crofts and Assinder, Limited.—Capital £30,000 in £1 shares (3,400 preference), to carry on the business of brass founders as formerly carried on by G. Crofts and G. F. Assinder, at Lombard Street, Birmingham, as Crofts & Assinder.

John Nicholson & Sons (Sheffield), Limited.—Capital £50,000 in £1 shares, to take over the business of steel manufacturers and general merchants carried on by R. and R. J. Nicholson at Mowbray, Sheffield, as John Nicholson & Sons.

Hamble River Engineering Company, Limited.—Capital £4,000 in £1 shares, to acquire the business of civil engineers, engine makers and repairers, etc., carried on by F. R. S. Bircham and S. Bircham, at or near Bursledon, Hants, as F. R. S. Bircham.

Foster (G. W.) & Company, Limited.—Capital £2,000 in £1 shares, to carry on the business of dealers, agents and manufacturers, engineers, etc., and to acquire the business carried on by G. W. Foster at 224, Pentonville Road, King's Cross. Registered office: 224, Pentonville Road, King's Cross, N.

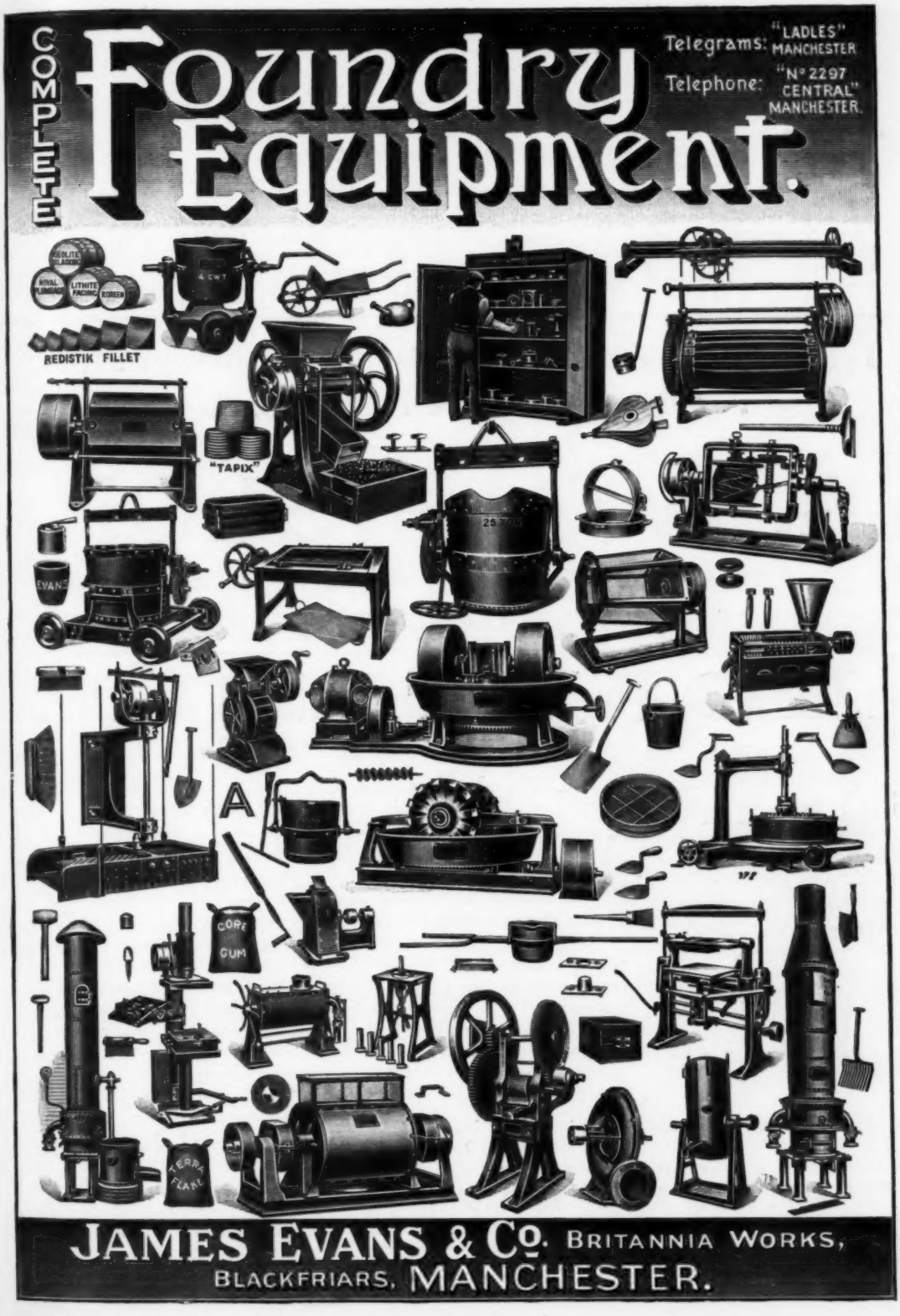
Osborne & Company (Dronfield), Limited.—Capital £12,000 in £1 shares, to take over the business of brass-founders and sanitary engineers carried on by R. and R. J. Nicholson at the Colonial Sanitary Works, Dronfield, Derbyshire, as Osborne & Company.

London Scaling Company, Limited.—Capital £15,000 in £1 shares, to take over the business of boiler cleaners and boiler and pipe coverers, carried on by J. Weir and J. H. Silley, as the London Scaling Company. Registered office: 155, Gracechurch Street, E.C.

Engineers' Standardised Publications Association, Limited.—Capital £2,000 in £1 shares, to take over the business of agents for the classification and distribution of manufacturers' trade circulars and price lists of engineering requisites carried on by F. Samuel and J. D. B. Innes at Craven House, Kingsway, W.C.

Mr. George Flett, an electrical engineer, was killed while driving a motor car at Birmingham last month. Mr. Flett was a director of the Metropolitan Amalgamated Carriage and Wagon Company, of Saltley, and managing director of Dick, Kerr & Company, Limited.

The death took place on July 25 of Mr. J. L. Hacking Riley, J.P., of Woodleigh House, Woolfold, Bury, principal of the firm of Messrs. J. H. Riley & Company, engineers, Elton Iron Works, Bury, Lancashire. The deceased gentleman, who was in his sixty-sixth year, was a member of the local Chamber of Commerce.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CORE GUM
JAMES EVANS & Co. BRITANNIA WORKS,
BLACKFRIARS, MANCHESTER.

Deaths.

Mr. E. Gittings, who was at one time a well-known Coseley iron manufacturer, died recently, aged 83 years.

The death occurred recently of Mr. T. Pryor, well known in connection with the tin industry, aged 75 years.

Mr. W. B. Sisling, one of the managing directors of Laurence, Scott & Company, Limited, engineers, of the Gothic Works, Norwich, died recently.

Mr. S. Lucas, at one time head of the firm of Messrs. Edward Lucas & Son, of the Dronfield Foundry and Spindle Works, Dronfield, near Sheffield, died recently.

Mr. W. Van Vleck Lidgerwood died recently at his residence in London, at the age of 78 years. Mr. Lidgerwood was the London representative of the Lidgerwood Manufacturing Company.

Mr. G. Wood died recently, at his residence, Brades House, Oldbury. The deceased, who was 76 years of age, was chairman of Hughes-Johnson Stampings, Limited, of the Langley Engineering Works, Langley, Birmingham.

Mr. R. R. Clark, commercial manager to Messrs. J. Williams & Company, Excelsior Iron Works, Wishaw, died recently. The deceased had been in the employment of the firm for over 40 years, and was widely known in the district.

The death is announced of Mr. L. Seil, a director of Turton Brothers & Matthews, Limited, crucible steel and spring makers, of Wentworth Street, Sheffield. The deceased gentleman was 64 years of age, and had spent 26 years with Messrs. Turton.

Mr. J. Waddington died on July 22, at Lancing, Sussex, in his 89th year. He was a son of Mr. Richard

(*Continued on page* 506.)

EFFICIENT AND ECONOMICAL HEATING OF FOUNDRY STOVES,
. . . ANNEALING OVENS, FURNACES, &c. . . .

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Gas Engineers, Underwood House, PAISLEY.

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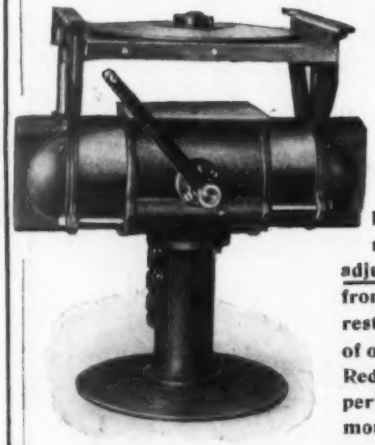

(STANDARD TYPE 'ADAPTABLE' MACHINE—EXTENDED)

It is six machines of its type in one, and the only truly adaptable machine built or protected by patents. ∴ Is quickly and easily adjusted, by means of a handle key, to accommodate any pattern plate of from twelve to twenty inches in width, the length of pattern being unrestricted. ∴ Will quickly draw patterns six inches deep to an accuracy of one-hundreth part of an inch. ∴ Can be operated by unskilled labour. Reduces cost of castings, increases capacity of foundry. ∴ Ensures perfect uniformity of castings; works deep and shallow patterns in one mould with equal success. ∴ Minimises floor space, is portable, and ∴ ∴ ∴ ∴ ∴ of convenient size. ∴ ∴ ∴ ∴ ∴

A Machine that Costs Little, Saves Much

For full particulars, please write to Manufacturers :—

THE ADAPTABLE MOULDING MACHINE CO., ENGINEERS AND . . . FOUNDRY SPECIALISTS,
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SOUND

STRONG, CLOSE-GRAINED

CASTINGS

Obtained by using

"TITANIUM THERMIT"

TINS READY FOR USE. **ALL SIZES from 2 cwt. to 20 tons.**

Prices and Particulars from

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ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Navigation Collieries, Ltd., Cardiff.

Waddington, whose firm, Messrs. Bray, Waddington & Company, of Leeds, constructed the ironwork for Victoria Bridge, the first railway bridge over the River Thames, in 1859. Mr. John Waddington had taken no active part in business for many years.

Mr. A. A. Hollingsworth, of Sheffield, died on Saturday last, after a long illness. Mr. Hollingsworth, who was the elder son of Mr. Alexander T. Hollingsworth, of Hampstead, had very close associations with Sheffield. He went to Sheffield as a young man, and joined the firm of Henry Bessemer & Company, Limited, steel manufacturers, eventually becoming a member of the directorate. He resigned this position a few years ago on account of a breakdown in health, and died at the early age of 38 years.

Mr. George Carmichael, for many years head of the firm of James Carmichael & Company, Limited, Ward Foundry, Dundee, passed away, at his residence at West Ferry, on the 10th ult. The deceased, who was about 89 years of age, had been in feeble health for many years, but the end came with startling suddenness. The firm was established by his father, Mr. James Carmichael, and his uncle, Mr. Charles Carmichael, who might also be said to be the pioneers of the engineering trade in Dundee. The deceased served his apprenticeship with the firm, and in due course became a partner, and subsequently senior partner.

Scrap.

The quotations for scrap, subject to market fluctuations, are as follows:—Heavy wrought (mixed), £2 10s. 0d.; light wrought, £1 7s. 6d.; heavy cast, £2 8s. 0d.; all per ton f.o.b., London. Copper (clean), £53 0s. 0d.; brass (clean), £38 10s. 0d.; lead (usual draft), £11 15s. 0d.; tea lead, £10 15s. 0d.; zinc, £18 10s. 0d.; all per ton delivered merchant's yard.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

Metals.	End Aug., 1910.	End Aug., 1909.
Iron—Scotch pig warrants ton	*56 0	*57 3
—Middlesbro' warrants . ton	50 1¼	51 4¼
—W.C. M/nos Bessemer ... ton	66 6	60 6
—Stock, Scotch ... .. tons	1,000	1,000
Copper—Chili bars, GMB ton	£56 6 3	£59 8 9
—Stock, Europe and afloat tons	196,927	180,852
Tin—English ingots ... ton	£152 10 0	£137 10 0
—Straits ... ... ton	£153 12 6	£138 2 6
—Stock, London, Holland, U.S.A., and afloat ...tons	—	—
Lead—English pig ... ton	£12 17 6	£12 17 6
Spelter—Ord. Silesian .. ton	£22 17 6	£22 0 0
Quicksilver (75lb)... bottle	£8 12 6	£8 5 0
Antimony—Regulus .. ton	£28 0 0-£30 0 0	£29 10 0 £30 10 0

* Settlement price. † Aug. 15.

Castings.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	6 10 0	to	6 15 0
Pipes, 1½ to 2½ in.	4 17 6	to	5 2 6
,, 3 to 4 in.	4 10 0	to	5 0 0
,, 5 to 8 in.	4 7 6	to	4 10 0
,, 10 to 16 in.	4 7 6	to	4 10 0
,, 18 to 24 in.	4 7 6	to	4 10 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 0 0	to	3 5 0

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
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Ironfounders' Charcoal Blacking, Mineral Blacking, Coal & Coke Dust Manufacturer,
&c.
JAMES SYKES, HURST CHARCOAL MILL, Near ASHTON-UNDER-LYNE.
ESTABLISHED 1864.

Established 1863.

JAS. DURRANS & SONS,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

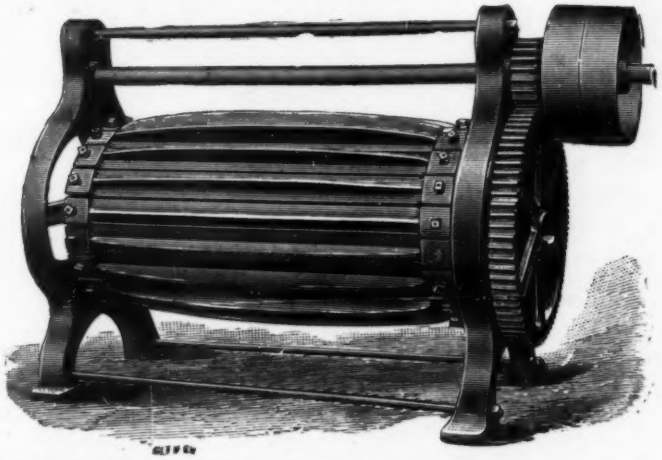
Manufacturers of all

FOUNDRY EQUIPMENTS,

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

HOW MUCH does RIDDLING by HAND Cost You?

Can You do it for 3d. per Ton?

That's just about the cost of Riddling with these **STAND AND WALL SAND RIDDLES.** The machines are arranged for belt drive, and to take ordinary 18 in. riddles. The holder has a simple catch so that the riddle can be changed in a few seconds. They are built to wear, take little power and floor space, and cost of maintenance is practically nil.

Price, Complete,

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Last month's sales and enquiries prove these machines are just what are required—STRONG and EFFICIENT POWER RIDDLERS at a low price.

We shall be pleased to book your order.

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TOTTENHAM, LONDON, N.

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Addresses and further information will be found by reference to the Firm's Advertisement.

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Jackman, J. W., & Co., Ltd.
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Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Sykes, James.
Olsen, Wm.
Walker, I. & I.
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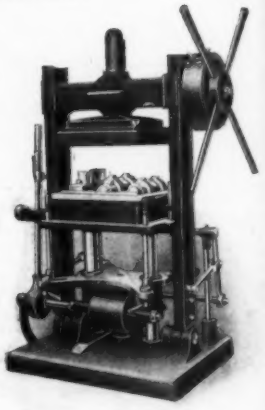

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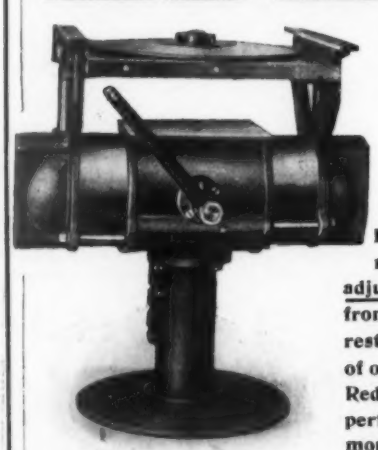

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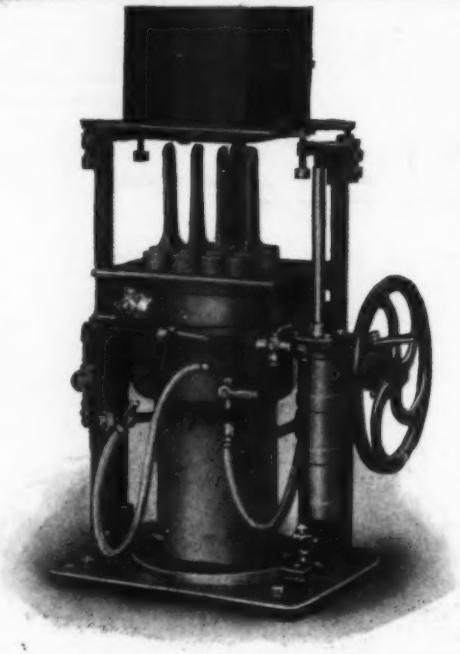

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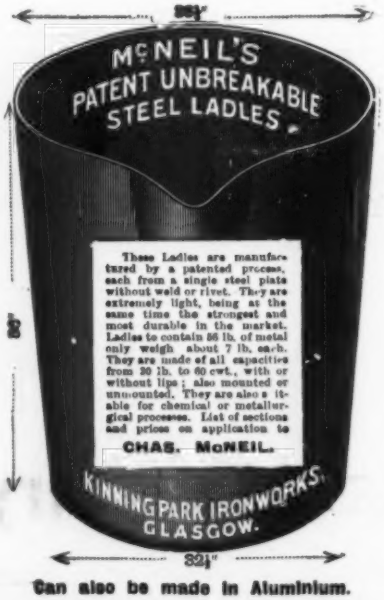
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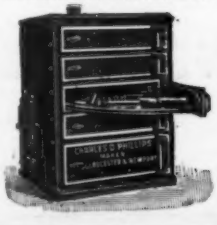

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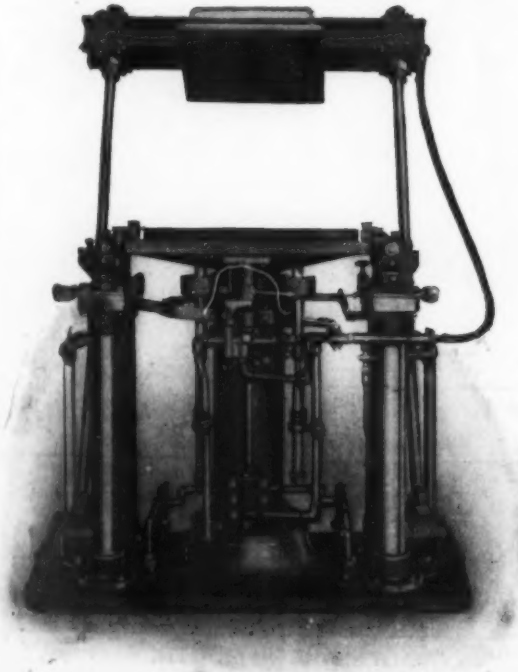

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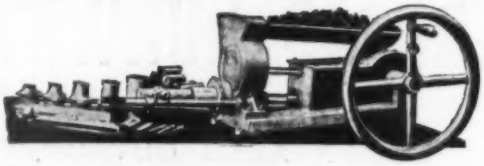

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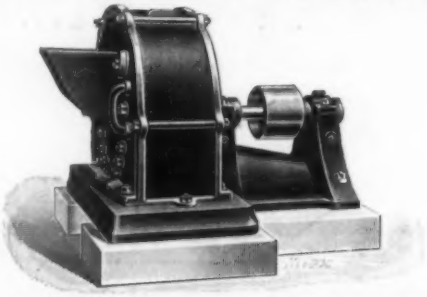

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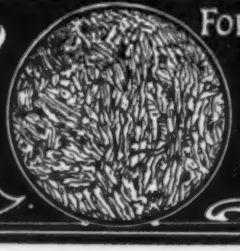

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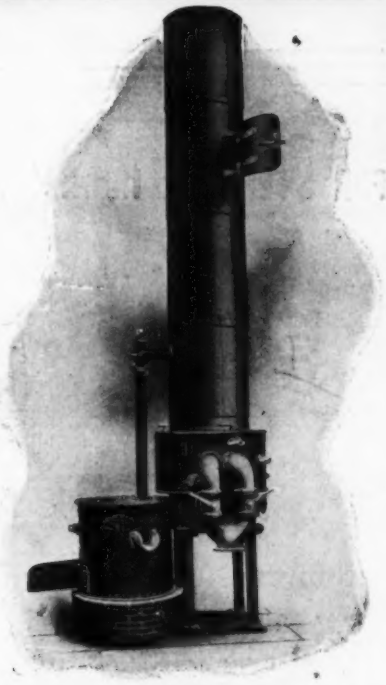

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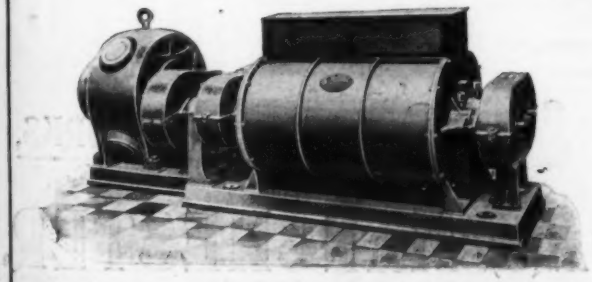

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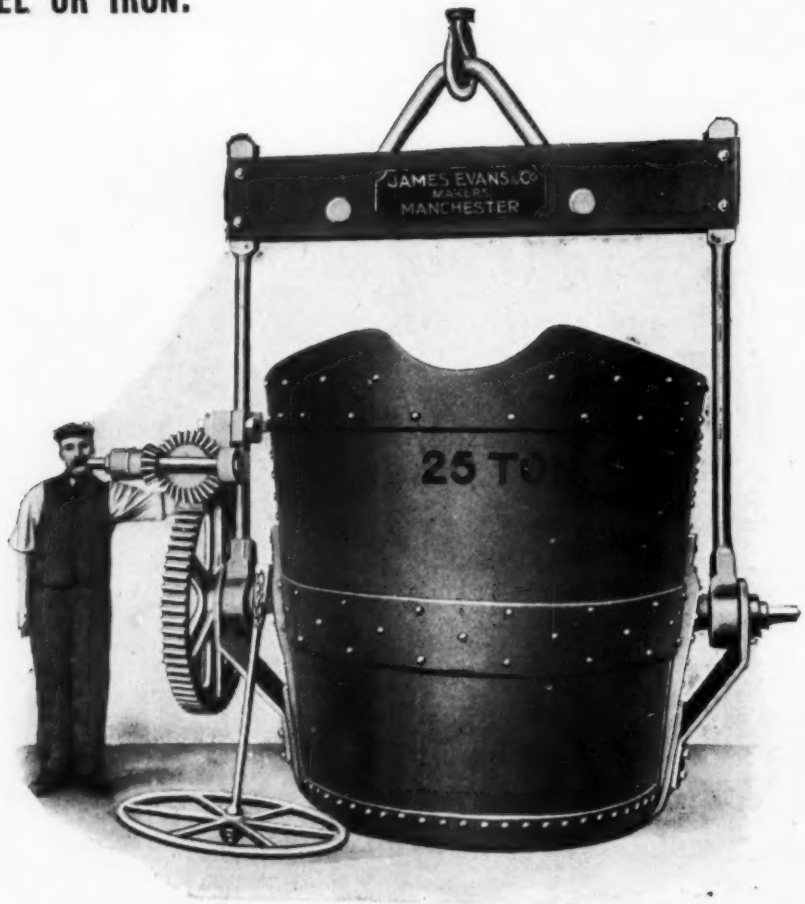

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